# FISCAL YEAR 1992 DEPARTMENT OF ENERGY AUTHORIZATION

## (Oil and Gas)

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# HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

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# 1992 DEPARTMENT OF ENERGY AUTHORIZATION

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## THURSDAY, MARCH 14, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY,
*Washington, DC.*

The subcommittee met, pursuant to recess, at 9 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd (chairman of the subcommittee), presiding.

## OPENING STATEMENT OF HON. MARILYN LLOYD, CHAIRPERSON, SUBCOMMITTEE ON ENERGY

Mrs. LLOYD. The subcommittee will come to order.

Today we continue with our second day of testimony on the Department of Energy's 1992 request for fossil fuels research and development activities. Our specific topic, oil and natural gas research activities, will be addressed from the perspective of industry, university and other non-governmental witnesses.

I am also very pleased that one of my good friends and colleagues, the Honorable Mike Synar from Oklahoma, is with us this morning. Congressman Synar will discuss the continuing need for responsible enhanced oil recover program. I certainly look forward to his testimony.

One focus of the recently released national energy strategy is achieving energy security by promoting advanced oil recovery. These technologies will recover significant quantities of oil that conventional technologies leave in the ground. The DOE budget request for the oil activities is $52 million. The funding level represents an actual decline in oil activities, but an increase in advanced and enhanced oil recovery development.

The oil shale activities funded last year, $17 million, has been zeroed out. The Department has funded oil shale activities on a very small scale for many years. I am very concerned that our research investment will go unrewarded if we cease our activities so prematurely.

We are also going to receive testimony on the Department's request for natural gas activities. In addition to the 50% decrease in the gas budget, the unconventional gas recovery program has been totally restructured. The industry driven, cost-shared program places a greater emphasis on near-term goals.

I question whether our prior year activities in eastern gas shales, western tight gas sands and environmental and advanced research have reached their logical conclusions. While I am not making a judgment about the restructuring of the program at the present time, I do have serious concerns about changing directions of the program without additional scrutiny.

Finally, I believe that the oil and natural gas programs should be a component of a domestic civilian energy research and development authorization bill. As our subcommittee works toward the passage of the legislation we will strive to set in place a sensible program by carefully focusing scarce research dollars.

Before we hear from Congressman Synar and other witnesses I would like to recognize the Honorable Lamar Smith for his opening statement.

## OPENING STATEMENT OF HON. LAMAR SMITH, MEMBER, SUBCOMMITTEE ON ENERGY

Mr. SMITH. Thank you, Madam Chair. It is my privilege to substitute for Mr. Morrison today, and to join you in welcome our guests who are here to testify on the Administration's oil and gas budget request for fiscal year 1992.

I am particularly pleased to welcome from my part of Texas Dr. Thomas Hyde of the University of Texas Permian Basin. I want to say specifically, Madam Chair, that I appreciate your agreeing to invite him today. I am looking forward to your remarks today, Dr. Hyde, and we had a chance a minute ago, and will continue, to discuss some issues that are of real importance to all of us.

DOE's budget submission for petroleum research focuses on increasing our ability to develop advanced extraction technologies. The oil research program implementation plan provides a much needed focus toward developing technologies to capture additional oil left behind by wells using conventional technology.

The recent crisis in the Persian Gulf demonstrates how vulnerable the United States can be to disruptions in our energy supply. I realize most new energy technologies that are under development are several years away from commercial application. Commitment to developing these critical technologies is needed by the Federal Government.

Thank you, Madam Chair.

Mrs. LLOYD. Thank you, Mr. Smith.

Mike, we certainly appreciate your leadership and your expertise in the Congress on so many issues. You are not ever afraid to step out and say what you think and certainly your district is well represented. They should be very proud of you and want to keep you here for a long time.

Mr. SYNAR. Marilyn, thank you very much, and I'm so glad I stayed around here so you could say nice things like that.

Mrs. LLOYD. Please proceed.

## STATEMENT OF HON. MIKE SYNAR, A U.S. REPRESENTATIVE FROM THE STATE OF OKLAHOMA

Mr. SYNAR. First of all, I want to thank you and Lamar and all of you for giving us this opportunity this morning.

The National Energy Strategy and the fiscal year 1992 Department of Energy budget really do offer little in the way of increased production in our lower 48 states. I want to focus on that and the research and development question this morning.

Instead of providing funds for research needed to bolster our sagging domestic oil and gas industry, the Administration has produced a plan which relies on politically unpopular, speculative and expansive production in the Arctic National Wildlife Refuge in Alaska and on the Outer Continental Shelf.

While the National Energy Strategy calls for a major increase in natural gas production and use, the Administration's 1992 DOE budget does not back up these fine sentiments with money. It proposes a cut in funding for natural gas extraction and R&D by 50 percent to a mere $8 million. It cuts gas turbines research by 100 percent to zero. It cuts research for high efficiency, low polluting fuel cells by almost 50 percent. Oil research is cut as well, from $59 million to $52 million.

Why is oil and gas R&D spending important? Lamar Smith can tell you why. It's very simple. Oil and gas together provide two-thirds of our primary energy in this country. One profitable area for increased oil research is the area of enhanced oil recovery. The widespread use of enhanced oil recovery could recover from 50 to 60 percent of the original oil within the reservoir. This increase in production works out to between 7.4 billion to 34 billion barrels of known oil.

In my State of Oklahoma alone, using a price of $20 per barrel, that would be oil worth about $16 billion that could be recovered using enhanced oil recovery. If enhanced oil recovery is to increase substantially, however, the Federal government should concentrate some of its R&D efforts on finding cheaper enhanced oil recovery techniques. But what we are finding, whether it be the biological method being pioneered by the National Institute of Petroleum and Energy in my own State in Bartlesville, Oklahoma, is that there is really nothing going on in that area.

We also need new tax relief for price stabilization that may be helpful in allowing us to fully utilize this area. Unfortunately, an estimated 75–80 percent of all the independent producers who will provide about 55 percent of that domestic production are unable to use the enhanced oil recovery tax credit enacted last year, because it is not credible against the alternative minimum tax.

The picture for natural gas research is no less urgent. Extraction research for natural gas, our cleanest fossil fuel, would be cut by 50 percent by DOE to a mere $8 million out of a total DOE budget of $16 billion and an energy R&D budget of $1.5 billion—only $8 million out of that total budget. Yet domestically produced natural gas offers significant environmental and efficiency advantages whether it is used as utility boiler fuel, vehicle fuels or emissions control fuel.

This newly-passed Clean Air Act, which all of us supported, will spur the need for natural gas in coal firing with coal and for gas reburning technologies to reduce harmful air pollution emissions. Improving these technologies should be a top priority for gas research.

The Clean Air Act and the President's National Energy Strategy also places heavy reliance on the use of alternative fuels vehicles, such as those running on compressed natural gas, for both energy security and reduced emissions. Under the President's plan, almost 100 million alternative fuels vehicles would need to be produced in a 15-year period in order to meet the Administration's energy security goals.

Unfortunately, the National Energy Strategy gives little guidance on ways to improve vehicle design, fuel storage and refueling. Fast refueling systems for compressed natural gas are currently so expensive that they may present a significant deterrent to the installation of this needed energy source. Alternative fuels technologies and applications are obviously a top research priority.

According to Deborah Gordon, author of one of the newest and most complete studies on alternatives to gasoline-fueled vehicles, compressed natural gas vehicles offer the best near-term alternative to gasoline powered vehicles. Her long-term favorite is the fuel cell, another natural gas technology which features high efficiency, low emissions and a longer vehicle life. Yet fuel cells, like compressed natural gas, are also underfunded in DOE's budget.

Finally, in my view, the energy budget must devote more effort to finding and producing natural gas. The National Energy Strategy assumes that natural gas demand will soar in the next decade from 18 trillion cubic feet produced last year to 24 trillion cubic feet in the year 2000. But will this increase come from domestic natural gas? The Administration doesn't care, because their projections show a large portion of this increase coming from imports. Without increased funding for gas supply and recover technologies, their projections may prove to be incorrect.

Madam Chairman, the 1980s were the lost decade for energy policy. Instead of building on the most successful programs of the mid-1970s, President Reagan dismantled almost every program on line for research, which could have made us less dependent on imported oil from unreliable countries. We have the opportunity to break this cycle of neglect and write a workable energy strategy for America. The key to that, I think, is improved oil and gas R&D, and it must play a major role in that plan.

Mrs. LLOYD. Thank you very much, Mike. Certainly we share your philosophy and your sympathies. This committee is certainly going to look not only at enhanced recovery technologies, but we will also be looking very hard at this budget for natural gas. Like you, we feel that one of the greatest potentials we have is our fuel cell program. To me, there is just too much there to dismantle what we have tried to do in this committee.

This committee has been trying to preach energy policy for the past decade, but it has been like yelling at the tide, there has not been a lot of response back. But we certainly hope we have your support as we try to push for restructuring in this program to the very best we can. We will certainly be working with you.

Let me ask you something. I feel that our money would be better spent on enhanced recovery technologies and fuel cell research and development than to spend money on the Arctic reserve. What do you think?

Mr. SYNAR. You hit a point which I think is going to really come to the juncture of this debate. That is that we may waste the better part of a year debating the Arctic National Reserve and offshore development, when in fact what we ought to do is focus in on the lower 48. Lamar and I, and all of us from our part of the world, were very disappointed with the neglect this energy strategy had with the available resources we have.

The lower 48 states literally offer 30 times the reserves that we will find in Alaska. We know where they are, all we have to do is go get them. We could literally increase 50 to 60 percent of the known things right there. We may waste a whole year trying to debate what I think, as I said, is a very unpopular, speculative, politically sensitive issue, when in fact if we put our focus on the lower 48, we could really serve this country in the immediate, middle and long term.

Mrs. LLOYD. Coming from a member, in the beginning of the year, I co-sponsored a bill to look into the Arctic Wildlife Refuge. I thought about it, as a member. I took my name off the bill, because I personally feel the money would be better spent in these areas, than to go in to an unknown, where we don't know what the capacity is, or what we will find. So I feel that this is certainly a better path to follow.

Lamar.

Mr. SMITH. Thank you, Madam Chair.

Mike, you are an able spokesman for any cause, but particularly for the oil and gas industry. I very much appreciate your comments today. I trust your constituents and others in Oklahoma will notice the fact that you are one member who has taken the time to come today and let us know how you feel, and how well you represent the industry.

I have to say to you that I am one who normally compliments the Administration. Yet I cannot quibble with what you have said today. There seems to be a wide gap in many instances between what the Administration says and what it does in the way of research and development money for oil and gas. As you are aware, the budget request was half what their own strategy suggested, and for the very reasons you mentioned.

I would also like to say that I agree with you in what you said about enhanced oil recovery. It seems to me that is very much a part of any energy strategy and were we to pay more attention to enhanced oil recovery we would be able to produce more oil, and that in turn would make us less reliant on foreign fuel and very much help the United States be energy independent.

I appreciate what you said. What we need to do and the work you and I have cut out for us is the fact that you and I come from two of 10 major oil producing states. Unfortunately, that gives us about a four to one ratio against us. But what we need to do is convince those of our colleagues from the other 40 states that we are really in this together. There is really no such thing as an energy policy for 10 states and another for the other 40. In fact, there is one energy policy and it needs to and can benefit members and citizens in all 50 states.

So I thank you for your comments today.

Mr. SYNAR. Thank you, Lamar.

Let me just say that your leadership in this area, particularly from your state, has been a great help. If this $30 billion to maybe $100 billion wake-up call we just got out of the Gulf is not enough of a notice that we have to rely upon our own resources, I don't think we will ever get the message.

Mrs. LLOYD. We certainly agree with you. I think one of the major field trips we should take this year is to put a little emphasis on what you just said, Mike. Maybe you will host a little trip out there for us, and show us around.

Thank you very much.

Mr. SYNAR. Thank you very much.

Mrs. LLOYD. Our first panel this morning will discuss natural gas research and development programs. Mr. George E. Strang is from the Southern California Gas Company and today is representing the American Gas Association. Mr. David O. Webb is Senior Vice President for Policy and Regulatory Affairs for the Gas Research Institute. Dr. Bernard Lee is President of the Institute of Gas Technology. Dr. Lee and Mr. Webb have appeared before our subcommittee many times. They are old friends of ours and we want to welcome them back.

Mr. Strang, we welcome you also, and we are going to ask you to be our lead off witness.

Your entire statements will be made a part of the record, so you may summarize as you wish. I would also like to tell our witnesses that we will be submitting additional questions to you in writing, in all likelihood, for the record, if you will respond to those as well.

Thank you.

## STATEMENT OF GEORGE E. STRANG, VICE PRESIDENT FOR ENGINEERING AND OPERATIONS SUPPORT, SOUTHERN CALIFORNIA GAS

Mr. STRANG. Thank you, Madam Chairman, and members of the subcommittee.

The American Gas Association represents some 250 natural gas distribution and transmission companies serving over 174 million natural gas consumers throughout the United States. We appreciate this opportunity to present our views on natural gas-related R&D sponsored by DOE.

Sharing a prevailing view that natural gas is an essential component of an effective energy policy, the natural gas industry developed strategies and assessed resource needs to make this fuel a key element in enhancing our Nation's future energy security, environmental quality, and energy efficiency. Given the scope of natural gas technology development, the current natural gas contribution to the national energy economy and the heightened concern with the environment, it rapidly became evident to us that the Federal Government should give natural gas related RD&D a larger and much higher priority in DOE's policy initiative and yearly budget.

Madam Chairman, you asked for a three-year projection, but the gas industry is also proposing a 10-year program of $2.5 billion, that truly supports the efforts and ideals laid out in the Clean Air Act and the National Energy Strategy. To inaugurate this program, the natural gas industry is recommending a $214.9 million authorization for fiscal year 1992 for all DOE gas-related RD&D. The major thrust of this expansion of gas-related RD&D is to develop the technologies that will allow natural gas to make a major contribution to the Nation's environmental and energy security needs.

Natural gas is our Nation's cleanest burning fossil fuel. Its combustion emits virtually no particulates or sulfur oxides, and it produces far lower emissions of ozone precursors, carbon monoxide, and other pollutants per unit of energy than coal or oil. AGA and the DOE National Energy Strategy estimate that natural gas could displace up to 1.7 million barrels of imported oil per day within 10 years. Intensified R&D programs focused on gas utilization technologies appropriately backed by continuing gas supply RD&D must be undertaken in order to expedite and expand this schedule and derive the accompanying environmental benefits.

There is a striking imbalance between the amount of natural gas used in the United States and the amount of RD&D funding natural gas receives. Natural gas supplies about 23 percent of America's energy needs, yet the Federal Government funded just over $117 million for gas-related RD&D in fiscal year 1991. That's less than eight percent out of the total DOE RD&D budget of approximately $1.8 billion.

In contrast, nuclear power provides about seven percent of the Nation's energy and received $503 million, and coal supplies about 25 percent of the energy and received about $680 million in fiscal year 1991.

The natural gas industry advocates private and public sectors share responsibility for funding RD&D. Where feasible, market incentives drive RD&D funding by an industry. However, in the case of secure energy, a clean environment and energy life-cycle efficiency, markets do not always adequately recognize these benefits that accrue to the Nation as a whole. This results in a lack of industry funding at conceptual and proof concept stages for viable technologies. This early life-cycle stage is where government must recognize its long-term responsibility by heavier than normal participation in the RD&D process.

The regulated gas industry supports organizations that promote specific technologies. Through GRI together with co-funding by gas utilities, the gas industry already matches the amount of DOE gas RD&D funding. The gas industry has developed a solid record of success when transferring technologies to commercial use. We have worked with numerous manufacturing and commercial partners to address the long list of issues to overcome before successful transfer can take place. Yet many promising candidates remain, requiring further support to move from laboratory to the marketplace.

I would like to cite a few of the specific funding recommendations for gas utilization RD&D that the industry is recommending for fiscal year 1992. The first is fuel cells. We recommend a total of $62 million. The electrical conversion efficiency of gas powered fuel cells is approximately 15 to 20 percent greater than the conversion efficiency of traditional electric generation. Fuel cells are also environmentally benign. They generate very little noise and vibration and emit virtually no pollutants.

The total of the $62 million should be used to support accelerated RD&D for molten carbonate fuel cells, for accelerated and focused development of solid oxide fuel cells technologies, and for intensified development of solid polymer fuel cell technology. We also recommend a vigorous technology transfer program for phosphoric acid fuel cells funded at $9 million.

The second area is heat engines. DOE's Heat Engine Program should include development of high efficiency natural gas-powered turbines in a wide array of sizes for electric generation. Such a program should include advanced combined cycle turbines, steam-injected gas turbines, and intercooled steam-injected gas turbines.

The third area of discussion today is coal and waste cofiring and reburn applications. Cofiring of coal with natural gas provides a fraction of its total heat input, and results in significant sulfur oxide and $NO_x$ reductions. Reburn technology is aimed primarily at reducing power plant $NO_x$ emissions. Coal firing technology applications to industrial processes and waste energy plants have not yet been addressed by DOE.

Developments in these areas will require significant funding to support technology advancements. A total of $17.8 million is needed to accelerate and focus combustion and burner RD&D efforts aimed at developing new low emissions gas equipment for residential, commercial, industrial and utility applications. Our recommendations include development of new methods of post-combustion emissions control that will promote the search for practical, low-cost solutions to typical retrofit/add-on needs of electrical generation and industrial process facilities.

We also recommend cofunding accelerated research specifically focused on utility electric generation and enhanced oil recovery operations using natural gas combustion equipment; and finally combustion systems development for the residential, commercial and industry sector.

For advanced research and technology development, we recommend $6 million. The advanced research and technology development program supports basic research in combustion chemistry, engineering concepts, advanced process development in materials and components and provides a technology base for ongoing fossil energy projects.

In conclusion, the natural gas industry recognizes the continuing budget deficit places severe constraints on Federal energy research dollars. However, increasing natural gas RD&D will more equitably match the contribution that natural gas supplies to the Nation's energy mix and will yield both short-term and long-term environmental and energy security benefits for the Nation.

Thank you.

[The prepared statement of Mr. Strang follows:]

# TESTIMONY OF
# GEORGE E. STRANG
# VICE PRESIDENT, ENGINEERING AND OPERATIONS SUPPORT
# SOUTHERN CALIFORNIA GAS COMPANY
# ON BEHALF OF
# THE AMERICAN GAS ASSOCIATION
# BEFORE THE
# SUBCOMMITTEE ON ENERGY
# COMMITTEE ON
# SCIENCE, SPACE AND TECHNOLOGY
# U.S. HOUSE OF REPRESENTATIVES
# ON THE FY 1992
# DEPARTMENT OF ENERGY
# RESEARCH AND DEVELOPMENT BUDGET

**March 14, 1991**

## Introduction

Madame Chairman and Members of the Subcommittee: The American Gas Association (A.G.A.) is a national trade association comprising some 250 natural gas distribution and transmission companies serving over 174 million natural gas consumers throughout the United States. We appreciate this opportunity to present our views on natural gas-related research, development and demonstration (RD&D) conducted or sponsored by the Department of Energy (DOE).

The American people recognize that greater energy security, improved air quality and energy efficiency are essential to a strong U.S. economy and helping us retain a competitive edge. Enactment of the Clean Air Act Amendments (CAA) and the various national energy strategy (NES) initiatives are a first step in reaching these goals.

Sharing the view that natural gas is an essential component to an effective energy policy, the natural gas industry developed strategies and assessed resource needs to make this fuel a key element in enhancing our nation's future energy security and environmental quality. Focusing on efficiency and emissions-related RD&D of gas equipment and processes, and on the gas supply/demand outlook, the gas industry identified funding levels necessary to contribute to a sound national energy strategy while helping to attain environmental goals. It rapidly became evident that, given the scope of natural gas technology development, the current natural gas contribution to the national energy economy, and the heightened concern with the environment, the federal government should give natural gas-related RD&D a larger and much higher priority in DOE's policy initiatives and yearly budget.

To define the goals of energy security, clean air and energy efficiency, the gas industry is proposing a 10 year RD&D program that truly supports the efforts and ideals laid out in the CAA and the NES. To inaugurate this program, the natural gas industry is recommending an authorization of $214.9 million for all DOE gas-related RD&D in Fiscal Year (FY) 1992. This includes programs in DOE's Fossil, Conservation and Renewable Programs. The primary thrust of this major expansion of natural gas related federally-funded research is to develop the technology that will allow natural gas to make a major contribution to the nation's environmental and energy security needs. Natural gas cannot fulfill its potential without the proposed RD&D.

## The Importance of Gas-Related Research

As an abundant domestic resource, natural gas can play a significant role in the nation's energy balance and has the potential to make a meaningful contribution in cleaning up the environment. Natural gas is our nation's cleanest burning fossil fuel -- its combustion emits virtually no particulates or sulfur oxides, and it produces far lower emissions of ozone precursors, carbon monoxide, and other pollutants per unit of energy than coal or oil. In addition, A.G.A. and the DOE National Energy Strategy estimate that natural gas could displace up to 1.7 million barrels of imported oil per day within 10 years. An A.G.A. analysis is attached. Intensified RD&D programs focused on gas utilization technologies appropriately backed by continuing gas supply RD&D must be undertaken in order to expedite and expand this schedule and derive the accompanying environmental benefits.

Past efforts of the gas industry along with DOE have repeatedly demonstrated the value of investing in gas-related RD&D. These efforts have led to progress in end-use technologies such as low-$NO_x$ combustion systems, cofiring, fuel cells, gas heat pumps, gas absorption chillers, and natural gas vehicles, and in supply research such as tight formations and coalbed methane.

Therefore, the gas industry recommends that Congress and DOE undertake a long-term (10-year) natural gas RD&D program funded at $2.5 billion to augment the planned industry funding. Programs should include: stationary emissions and efficiency solutions; transportation fuel alternatives and emissions solutions; electrochemical energy conversion; and gas supply enhancement. A comprehensive 10 year program is necessary to provide a level of consistency in research efforts that can support projects through to their completion and commercialization.

To initiate these programs we recommend that Congress authorize $214.9 million in FY 92 for natural gas RD&D. These funds should be allocated as follows: (1) $165 million in DOE's fossil and conservation programs for natural gas utilization programs to accelerate the availability of new technologies and reap the associated environmental, energy security and conservation benefits. $49.9 million in DOE's fossil program is needed to support a continuing natural gas supply RD&D program. This will supplement gas industry, gas equipment manufacturer, and producer efforts with estimated funds in the range of $200 million and $215 million in FY 92 for utilization and supply, respectively.

This natural gas industry initiative requires funding only for those technologies that are essential and prudent for the orderly development of advanced and new gas utilization and supply methods and processes that will enhance greater energy security, improved air quality and energy efficiency. Recent events in the Middle East underscore the need for better utilization of our nation's indigenous resources. This recommendation for a total amount of $214.9 million is required because of the increasing urgency to promote low pollution end-use technologies and fuel efficiency. This in turn will help meet more ambitious national objectives that will take us into the 21st Century.

We believe it is imperative that members of the Subcommittee work closely with the Appropriations Committee to assure that these programs are brought to fruition. There is a striking imbalance between the amount of natural gas used in the United States and the amount of RD&D funding natural gas receives. Natural gas supplies about 23 percent of America's energy needs, yet the federal government spent just over $117 million for FY91 on gas-related R&D, out of a total DOE R&D budget of approximately $1.8 billion. In contrast, nuclear power provides about 7 percent of the nation's energy and received over $503.2 million, while coal supplies 25 percent of the energy and received about $680 million in FY91. Please understand we are not attempting to identify or recommend the source of funds needed to meet the increased federal funding for natural gas RD&D.

## Co-Funding of Research

The natural gas industry advocates that the private and public sectors share responsibility for funding RD&D. Where feasible, market incentives drive RD&D funding by an industry. However, in the case of secure energy, a clean environment and energy life-cycle efficiency, markets do not adequately recognize those benefits that accrue to the nation as a whole. This results in lack of industry funding at the conceptual and proof of concept stages for viable technologies. This early life-cycle stage is where government must recognize its long term responsibilities by heavier than normal participation in the RD&D process. It has to be understood by government that, by achieving a balance in energy technology choices, the nation as a whole benefits, not just the direct users of the technology.

Traditionally, the R&D phases are the lowest component of the total path from basic research to successful commercialization. When a product progresses to the stage where the technology is ready to be transferred from the laboratory into the commercial market -- that is the logical point that industry takes on a higher percentage of funding. Therefore, legislation must not predetermine the federal share of the cost of a project at any particular stage in its development.

The regulated gas industry supports organizations that promote specific technologies. GRI is the natural gas industry's cooperative research and development organization with membership from the pipeline, local distribution company and producer segments of the industry. Through GRI, together with co-funding by gas utilities, the gas industry already matches the amount of DOE gas RD&D funding. The American Gas Cooling Center, the Natural Gas Vehicle (NGV) Coalition and NGAGE (Natural Gas Alliance for the Generation of Electricity) devote their efforts to commercialization of specific types of gas equipment and applications. The A.G.A. Laboratories also successfully perform R&D that has direct application to appliance and equipment innovations. IGT has established a Sustaining Membership Program in which over 50 gas companies support mid-term research directed toward a wide variety of projects, primarily in gas utilization.

However, relative to attaining environmental goals and improving U.S. energy security, these industry-funded RD&D programs are limited by available funds. Inevitably, projects with greater benefits for gas users and realistic chances of early commercialization are pursued while more far-reaching projects that have a potentially high impact on society cannot be funded. In addition to the development of new gas technologies, demonstrations and other technology transfer activities are necessary to ensure that the money spent in the research is not wasted. The gas industry has developed a solid record of success in transferring technologies to commercial use. We have worked with numerous manufacturing/commercialization partners to address the long list of issues to be overcome before successful transfer can take place. Yet many promising candidates remain, requiring further support to move from the laboratory to the marketplace.

## Specific Funding Recommendations for FY 1992

## GAS UTILIZATION R&D: $165.0 MILLION

### (1) Fuel Cells ($62.0 million)

Natural gas-powered fuel cells convert the energy content of gas directly into electricity and by-product heat using a highly efficient electrochemical process. The electrical conversion efficiency of gas-powered fuel cells is approximately 15-20 percent greater than the conversion efficiency of traditional electrical generation. Fuel cells are also environmentally benign, generating very little noise and vibration, and emitting virtually no pollutants.

A total of $38.5 million should be used to support accelerated RD&D for molten carbonate fuel cells and $10.5 million should be used for accelerated and focused development of solid oxide fuel cells technologies. Furthermore, $2.0 million should be allocated for intensified development of solid polymer (proton exchange membrane) fuel cell technology. This is a promising new approach to the development of fast-response, compact fuel cells with low temperature heat rejection, suitable for electric power generation in stationary as well as mobile use. An additional $2.0 million should also be allocated to applied fuel cell research covering projects aimed at using solid polymer cell concepts in small-scale electric power generation, and projects that seek to improve the reliability and life of critical fuel cell components. To date, the gas and electric industries and DOE have jointly invested over $200 million in R&D for phosphoric acid fuel cells. We therefore, recommend a vigorous technology transfer program for these fuel cells funded at $9 million.

### (2) Heat Engines ($6.9 million)

A.G.A. recommends an RD&D program in DOE's Heat Engine Program for the development of high efficiency natural gas-powered turbines in a wide array of sizes for electric generation. Such a program should include advanced combined cycle turbines, steam-injected gas turbines (STIG) and intercooled steam-injected gas turbines (ISTIG). The ISTIGs, in particular, are approximately fifty percent more efficient than conventional powerplants, cost half as much as new coal or nuclear plants and can make great contributions to the nation's air pollution problems. The need also exists for RD&D efforts aimed at other engines. Such efforts must adapt the latest liquid-fueled engine technology to dedicated natural gas engines that produce shaft power for water pumping, gas compression and various industrial and commercial applications.

### (3) Coal and Waste Cofiring/Reburn ($8.5 million)

Cofiring of coal with natural gas provides a fraction of its total heat input and results in significant $SO_2$ and $NO_x$ reductions. Reburn technology is aimed primarily at reducing powerplant $NO_x$ emissions. Unlike cofiring, reburn technology injects natural gas into a zone beyond the primary combustion zone to create a gas rich reburn zone. Pilot scale tests indicate gas reburning in cyclone boilers could potentially reduce $NO_x$ emissions by more than 60 percent. This is particularly significant as no other validated $NO_x$ reduction technique exists for these boilers. Combining reburn with sorbent injection results in both $NO_x$ and $SO_2$ reductions.

The gas industry applauds the efforts of DOE in supporting the development of cofiring technologies as part of its Clean Coal Technology Program. The gas industry encourages DOE to continue its program to support further advances of cofiring technologies such as NOXSO, a dry regenerative sorbent process, and the Parsons catalytic reduction process to reduce $NO_x$ and $SO_2$ by levels greater than 90 percent.

Cofiring technology applications to industrial processes and waste-to-energy plants have not yet been addressed by DOE. Developments in these areas are at the early stages, but will require significant funding to support technology advancements. We therefore recommend $8.5 million for coal and waste cofiring and reburn applications.

### (4) Combustion System/Emission Control ($17.8 million)

Because of the importance of this program to the nation as part of its energy strategy and in response to recently-adopted Clean Air Act legislation, $17.8 million is needed to accelerate and focus combustion and burner RD&D efforts aimed at developing low emissions gas equipment for residential, commercial, industrial, and utility applications. This includes high-efficiency, low-emissions burners, burner systems, and new methods of post-combustion control for new as well as retrofit installations.

Our recommendation includes: $6.0 million for the development of new methods of post-combustion emissions control that will promote the search for practical, low-cost solutions to typical retrofit/add-on needs of electric generation and industrial process facilities; $5.3 million for co-funding accelerated research specifically focused on utility electric generation (UEG) and enhanced oil recovery (EOR) operations using natural gas combustion equipment; and $6.5 million for the residential/commercial end-use sector.

### (5) Natural Gas-Powered Heat Pumps and Desiccant Cooling ($18.0 million)

The gas heat pump provides heating and cooling in a single unit, using less energy than a conventional or high efficiency furnace uses for heating alone. Current performance estimates suggest that in heating, the gas heat pump could save one-half of the gas used in a conventional furnace and one-quarter of the gas used in a high efficiency furnace. The gas heat pump is attractive because it can provide cost-effective cooling in most warm regions where electric prices and demand charges are structured to discourage load growth. In addition, use of gas heat pumps could help to level cyclic gas and electric demand profiles, favorably affecting utility operating expenses and the cost of energy to the consumer.

More research is necessary to develop highly-efficient, reliable and cost-effective gas heat pumps for residential and commercial applications. Specifically, research in basic heat pump processes and phenomena, advanced working fluids and materials, use of non-ozeotropic refrigerant mixtures, advanced absorption systems for large commercial chiller and liquid and solid desiccants, is needed to put the advantages of gas heat pumps to work.

### (6) Industrial Processes ($18.8 million)

We recommend $7.8 million to demonstrate newly developed processes in real-world industrial environments, not laboratories. Several innovative concepts, which promise to revolutionize the manner in which process heat is generated in the industrial sector, are under development and will be available for technology transfer within the next two years. Applied RD&D efforts, funded at $4.0 million by DOE are also proposed to improve efficiency, productivity and product quality in industrial gas-fired equipment and processes through the application of advanced combustion, heat transfer and controls technology. The gas industry is also recommending that $6.0 million be allocated for research and development focused on low emissions of natural gas combustion equipment for this sector. These funds will cover activities to help extend application of technologies employed in UEG/EOR end-use sectors to industrial processes and to obtain fundamental understanding on the formation and recombination of pollutants. Continuing ceramic material RD&D funded at $1 million is also needed to address several technical issues that have impeded wide market penetration.

### (7) Natural Gas Vehicles (NGVs) ($27.0 million)

Use of alternative-fuel vehicles, including NGVs, is being required by the Clean Air Act and various National Energy Strategy initiatives. Accelerated research on novel gas compression concepts, funded at $10 million, is required to advance the development of compressor technology that will facilitate the growth of the necessary natural gas refueling network. Research must also be conducted on advanced storage systems, such as sorbent materials, to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

In addition, $15 million in DOE funding is also needed to conduct accelerated technology transfer on a variety of NGVs in many medium and heavy duty applications. To be most effective, such technology transfer activity requires that the government purchase and operate NGVs for its fleet.

### (8) Advanced Research & Technology Development (ARTD) ($6.0 million)

The Advanced Research and Technology Development program generally supports basic research in combustion chemistry, engineering concepts, advanced process development, and materials and components that provide a technology base for ongoing fossil energy projects. Current research needs include: development of advanced high-temperature materials capable of resisting chemical attack from sodium and chlorine for application in glass and aluminum melting; development of inexpensive and durable catalysts to bring natural gas catalytic combustion closer to practical implementation; improving the understanding of the interaction of gasification catalysts with carbon/steam and carbon/hydrogen reactions; developing advanced processes for low-cost synthesized gas; developing lower-cost acid-gas cleanup processes; continuation of efforts to assess advanced technology for alkali metals, particulates and tars; and biological and catalytic production of high-value chemicals.

## GAS SUPPLY RD&D: $49.9 MILLION

DOE's continuing involvement in gas supply research is essential to ensure the recovery of a larger percentage of the total domestic gas resource base. Our recommendation of $49.9 million for FY 92 shows no increase above the industry's recommended FY 91 funding levels and is predicated on the continuation of the gas supply research programs recommended for FY 91.

Estimated consumption of natural gas in 1989 was 19.3 quads. Current domestic production is running at about 17.8 quads annually with the balance of demand met by other sources such as storage, supplemental gaseous fuels, and natural gas imports.

The amount of gas that can be recovered from the total gas resource base is directly contingent upon the ability to develop new tools and techniques to recover this gas at commercially viable prices. This resource base is made up of reserves and resources. The recovery of gas in the "resources" category requires discovery and development of **new** technology on the basis of an improved understanding of reservoir geology. Of the total resource evaluated in the lower-48 states 564 Tcf is judged economically recoverable at 1987 wellhead prices of less than $3/Mcf. An additional 131 Tcf of gas is judged economically recoverable in a price range of $3 to $5/Mcf.

### (1) Unconventional Natural Gas ($23.8 million)

Devonian shales and tight sands are estimated to contain up to 1,800 Tcf and 900 Tcf of natural gas, respectively. Tight formation gas is produced using advanced recovery techniques, such as hydraulic fracturing. A.G.A. estimates that favorable economic conditions and substantial investment in advanced recovery techniques could increase the accessible gas resources and improve the economics of production.

In order to maximize the amount of natural gas recovered from our abundant resource base, basic geoscience research must be expanded. This research should be aimed at increasing our knowledge of the geological/geochemical/geophysical characteristics and parameters of both conventional and unconventional formations. Moreover, because of the potentially enormous size of what we call advanced unconventional natural gas resources, extensive research is necessary to verify how much may be technologically and economically recoverable.

To enhance the development of technology necessary to recover the gas from unconventional gas formations, more research must also be conducted to develop and refine advanced stimulation and drilling techniques (directional and horizontal). Field testing and a technological database must also be established. We are recommending funding of $23.8 million in the unconventional gas recovery program to continue DOE's secondary gas recovery program and ongoing research activities in western tight stands, Devonian shales, and other complex formations and to support expanded geoscience-type research.

### (2) Surface Coal Gasification ($8.5 million)

For surface coal gasification to make a significant contribution to gas supplies, gasification techniques must be developed to accommodate high-sulfur Eastern coals and combustion-inhibiting coal "fines." Research must be conducted to develop techniques for gasifying these "fines," for disposition of liquid byproducts, and for consolidated "fines" and tars for utilization. Scientific and engineering feasibility studies of advanced generation gasification processes must also be conducted to develop a technological database for such processes.

### (3) Geopressured Methane ($9.6 million)

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-place range up to 6,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered, given current recovery techniques, range between 10 and 150 Tcf. If technological breakthroughs can be achieved, geopressured methane could become another major source of domestic energy.

Research conducted by DOE in geopressured/geothermal zones is focused on producing both gas and electricity from low-grade heat in the reservoir brine. DOE should redirect its research efforts and concentrate on recovering the vast amount of dissolved methane found in geopressured zones. In addition to DOE's current geopressured program, DOE should develop new approaches that utilize traditional engineering principles to maximize gas production and minimize brine production.

### (4) Biofuels ($8.0 million)

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. In addition, controlled production and use of methane from these sources can reduce the natural release of methane from the decay of these waste materials. This decay is a substantial contributor to the overall rate of methane emissions to the atmosphere that contribute to the greenhouse effect. Finding sites for disposal of municipal solid waste is an increasing problem in communities across the nation. Therefore, developing energy from municipal solid waste and other biomass would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespread use of these potential gas resources.

The gas industry fully supports the gas-related biofuels R&D being carried out at the Solar Energy Research Institute (SERI) and recommends strong federal support for continuation of these important activities. Advances have been made in both the thermochemical and biochemical conversion processes, but more extensive studies and technology advancements are necessary to fulfill biomass' contribution as a usable source of energy.

## Conclusion

The natural gas industry recognizes the continuing budget deficit places severe constraints on federal energy research dollars. However, increasing natural gas RD&D will more equitably match the contribution natural gas supplies to the nation's energy mix and will yield both short- and long-term environmental and energy security benefits for the nation.

## DOE FY 1991 & 1992 Gas-Related Budget

Major Gas-Related Supply and Utilization Research Programs
($ Millions)
(As of 2/12/91)

| | FY 1990 Congress. Approp. | FY 1991 DOE Request | FY 1991 Gas Industry Recomm. | FY 1991 Congress. Approp. | FY 1992 DOE Request | FY 1992 Gas Industry Recomm. |
|---|---|---|---|---|---|---|
| **Gas Supply** | | | | | | |
| Unconventional Natural Gas | 14.6 | 13.7 | 23.3 | 15.97 | 8.0 | 23.8 |
| Surface Coal Gasification | 23.7 | 8.5 | 8.5 | 15.12 | 5.4 | 8.5 |
| Underground Coal Gasification | 0.8 | 0.5 | 0.5 | .794 | 0.0 | 0.0 |
| AEPT* | 4.0 | 4.5 | - | 4.67 | 3.0 | - |
| Biofuels | 8.6 | 2.5 | 8.0 | 4.6 | 6.3 | 8.0 |
| Geopressured Resources | 6.0 | 2.9 | 9.6 | 6.0 | 2.5 | 9.6 |
| Subtotal | 57.7 | 32.6 | 49.9 | 47.15 | 25.2 | 49.9 |
| **Gas Utilization** | | | | | | |
| Fuel Cells (Gas Related) | 30.1 | 7.1 | 40.5 | 36.02 | 22.4 | 62.0 |
| Heat Engines | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 6.9 |
| Combustion--Cofiring/Reburn | 2.5 | 0.0 | 8.5 | 0.0 | 0.0 | 8.5 |
| Combustion--System/Emiss. Cont. | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 | 17.8 |
| Conservation (Heat Pumps, Cooling, Industrial Processes) | 25.4 | 17.8 | 16.8 | 25.1 | 16.7 | 36.8 |
| Natural Gas/Diesel Vehicles | 2.5 | 4.0 | 10.6 | 5.5 | 12.5 | 27.0 |
| ARTD (Gas Related) | 4.7 | 3.9 | 6.0 | 3.9 | 1.0 | 6.0 |
| Subtotal | 65.2 | 32.8 | 85.8 | 70.52 | 53.2 | 165.00 |
| TOTAL | $122.9 | $65.4 | $135.7 | $117.67 | $78.3 | $214.90 |

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*Advanced Extraction and Process Technology - Geoscience research has traditionally been folded into this line item.

AGA American Gas Association

Planning & Analysis Issues

Issue Brief 1991-3 January 16, 1991

## The Role of Natural Gas in Offsetting Oil: 1991 Update

### A. Introduction

The invasion of Kuwait in August has brought the subject of U.S. dependence on oil imports to the forefront again. America now imports about half of the oil that it consumes. Most oil is used in the transportation sector, however, a large volume of fuel oil is also used in stationary applications: for space heating; for industrial process and boiler use; and [illegible] electricity generation. Oil use in stationary applications (excluding feedstocks) in 1989 amounted to 4.9 million barrels per day (b/d), or the equivalent of 68% of annual crude oil imports. Distillate and residual fuel oil, the oil products most likely to be offset by gas, make up half of that total. In contrast, natural gas is essentially a domestic resource with over 40 years of conventional supply under current consumption rates and the potential to extend the resource base well beyond the next century.

The purpose of this analysis is to demonstrate the extent to which natural gas can directly contribute to national energy security by substituting for oil in existing applications. This study updates a similar analysis published by A.G.A. in 1988. This analysis was prepared on a market-by-market basis over different time horizons: 30-day (immediate); 1 year; 5 years; and a 10-year potential. This analysis estimates oil displacement potential - it is not a forecast. Such levels would only be achievable if government policy actively promotes natural gas.

### B. Executive Summary

In an emergency or oil supply disruption scenario natural gas could immediately offset 130 thousand barrels per day (mbd) of distillate and residual fuel oil in stationary applications. Within a year the rate of displacement could increase to 420 mbd as significant penetration in the dual-fuel capable boiler markets accumulates. After five years, the combination of growing conversions in the residential and commercial buildings sector (mainly on the East Coast) and further penetration in boiler and process markets would raise the penetration rate to 1.0 million b/d. If a comprehensive government initiative was begun now with a 10-year horizon, it is estimated that 1.5 million b/d of fuel oil use could be offset by the end of the decade. Adding 240 mbd that would, in effect, be offsets of gasoline use in fleet vehicles in the transportation sector, would bring total oil displacement by natural gas to 1.7 million b/d after 10 years.

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An important component of this initiative would be increased natural gas pipeline capacity into oil-dependent regions. The volume of current planned natural gas pipeline capacity would go substantially toward accomodating the projected level of oil displacements over five years. To achieve the ten year goal, a similar increment in pipeline capacity and an increase in gas storage capacity would be needed. The exact size of the increment is dependent upon seasonal load factors and upon the volume of additional gas load that would derive from economic growth and other new sources.

The highlights for each stationary market and for the transportation sector for each succeeding timeframe are as follows and summarized in Table 1:

- The residential market for fuel oil is essentially distillate oil use concentrated on the U.S. East Coast, particularly in the Middle Atlantic census division which accounts for 5.6 million of the 11 million oil-heated households. Conversions from oil to natural gas heat already comprise the single largest source of residential conversions annually. Based on previous conversion growth rates it is possible to envision 350,000 conversions in the first year, displacing 20 mbd, rising to 500,000 conversions annually by the fifth year, resulting in oil offsets of 100 mbd after five years. If the annual rate of conversions then holds at 500,000, the cumulative potential impact after 10 years would be the displacement of 225 mbd of distillate fuel oil use -- roughly half of the current consumption level. This ten year goal would require additional pipeline and storage capacity and distribution mains given the seasonality and location of this load.

- In the commercial market, both distillate and residual fuel oil are used - primarily for spaceheating, but also for water heating in large multi-family buildings. Similar to the residential sector, commercial fuel oil consumption is also concentrated on the East Coast, but to a lesser extent. In the event of an oil supply disruption, displacement of oil use in dual-fuel boilers could reach 25 mbd. After a year, the displacement of all oil in gas-served buildings, as well as in a portion of the more than three million multi-family units with gas service nearby, would increase the offsets to 100 mbd. With increased penetration in the multi-family sector, the offsets could reach 190 mbd after five years and as much as 250 mbd after 10 years, or nearly 65 percent of the current level of commercial fuel oil use.

- The industrial market is the largest stationary market for fuel oil. Even after discounting those oil applications for which natural gas is not suited for displacement (such as feedstocks, asphalt and vessel bunkering) there remains nearly 900 mbd of distillate and residual fuel oil use in boiler and process applications that theoretically could be displaced by natural gas. Oil offsets could rise from 50 mbd in the immediate term to 200 mbd after a year. This would occur predominantly in dual-fuel boiler applications where gas and residual oil, in particular, are intensely competitive. After five years, when gas penetrates more into the applications using distillate oil, the offsets are projected to increase to 400 mbd. If there is, in fact, a policy designed to minimize the use of oil in industrial applications, the extension of gas service to a high proportion of what had formerly been unserved customers could potentially see the level of offsets reach 600 mbd after 10 years. While certainly a large volume, this would only be about 15 percent of all the oil consumption (including LPG) in the entire industrial market and two-thirds of the residual/distillate oil use. Like the residential and commercial sectors, displacement of oil in the industrial market to meet the ten year goal will require significant new construction of pipeline and distribution infrastructure. Seasonal service arrangments would also have to be enhanced.

- Fuel oil consumption (almost entirely residual oil)in the electric utility market is heavily concentrated on the East Coast. Over 80 percent of this oil consumption occurs in the three census divisions along the Atlantic. Unlike the industrial market, which is made up of thousands of customers and more widely distributed, the number of power plants involved is relatively small. About 125 of the 290 or so power plants that use fuel oil are on the East Coast -- and some of these plants are already dual - fuel capable. Consequently, the potential for oil offsets rises quickly from 50 mbd in the very short - term to 300 mbd after five years. With a concentrated national effort, three - quarters of fuel oil consumption could be offset in 10 years, reaching 400 mbd. Given the location of these plants, it is likely many plants would choose to be dual-fuel capable, interruptible gas customers. Thus complete displacement of oil year-round would be unlikely.

- In the transportation sector the displacements would be limited in the early years, reflecting the fact that a natural gas vehicle (NGV) manufacturing and fuel distribution infrastructure is now beginning to develop. The oil displacement rate would move up from minimal levels in the first five years, rising quickly by the end of the decade to 240 mbd as 2 million centrally-refueled fleet vehicles in major urban areas convert to natural gas. The passage of the Clean Air Act of 1990 alone will spur oil offsets in the transportation sector.

Table 1

**Potential Oil Substitution**
**(thousand barrels/day)**

| **Stationary Sources** | **Immediate** | **One-Year** | **Five-Years** | **Ten-Years** |
|---|---:|---:|---:|---:|
| Residential | 5 | 20 | 100 | 225 |
| Commercial | 25 | 100 | 190 | 250 |
| Industrial | 50 | 200 | 400 | 600 |
| Electric Generation | 50 | 100 | 300 | 400 |
| **Subtotal** | **130** | **420** | **990** | **1475** |
| **Mobile Sources** | | | | |
| Vehicles | - | - | 5 | 240 |
| **Total** | **130** | **420** | **995** | **1715** |

Note: NGV market penetration grows dramatically after five years as a result of the new Clean Air Act legislation which begins to take effect in 1995. A.G.A. forecasts that by the year 2005 natural gas vehicles could displace as much as 675 mbd.

Mr. STALLINGS. Thank you very much, Mr. Strang.

Mr. Webb, if you would like to begin.

## STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT FOR POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE

Mr. WEBB. Thank you very much, Mr. Chairman and members of the committee.

I am David Webb, and I appreciate the opportunity to be here today to present GRI's fiscal year 1992 budget recommendations of $23.8 million for the DOE's natural gas supply research program. I want to note that this recommendation is only one part of the $215 million budget that the gas industry proposes for all gas-related research, in the total DOE budget. A table in my testimony details the $215 million proposal.

However, today as you requested, I will present detailed testimony on GRI's budget recommendation for the natural gas research program in the fossil energy program in DOE. Within this recommendation of $23 million, specific programmatic research funding recommendations are as follows: For Eastern Devonian Shales, $3 million to continue the program Congress funded last year; Western Tight Sands, $5 million; $5 million for Technology Transfer efforts which we propose be funded 50–50 with the gas industry; with Environmental Research, Integrated Data Base activities, Speculative Resources and Subquality Gas Processing making up the remainder of that.

Central to this recommendation are GRI's plans, and the gas industry through GRI, to fund approximately $52 million of gas supply research in 1992 and GRI's commitment to co-fund DOE's field-based activities. Three major Federal and Congressional actions have occurred during the past year that indicate energy policy which encourages significant expanded roles for natural gas.

Last April, DOE published the Gas Research Program Implementation Plan, projecting a five-year budget for natural gas with an average of $22 million a year over the five years. In October, Congress passed the Clean Air Amendments of 1990, setting in place actions to reduce emissions from mobile and fixed sources, thereby placing a premium on clean burning fuels such as natural gas.

Then just last month, the Administration released its National Energy Strategy. One of the three primary goals was to encourage the efficient production of natural gas in an environmentally sound manner. The proposed approach in the NES to achieve the goal was to support R&D on better technologies for natural gas production, and finally, the stated implementation plan in accordance with the NES R&D framework was to emphasize a joint government-industry R&D consortium with an expectation of 50 percent co-funding.

However, despite the NES policy of support for implementing the DOE gas research plan, the 1992 budget for natural gas supply is only $8 million, one-half of last year's appropriation, and certainly not the $22 million required to implement the DOE plan. Congress should fund the DOE plans so that a true joint government-gas industry program can be implemented, to allow gas to fulfill its potential.

A couple of indications of the imbalance in the budget can be seen if you look at electric-related R&D compared to gas R&D, the ratio is over 20 to 1. That imbalance just cannot be justified from the standpoint of the way energy is used in this country. Natural gas is used for about 23 percent of the energy in this country, yet the natural gas supply research budget is less than one percent of the energy R&D budget in DOE.

I think in determining whether it is feasible to expand gas use to meet some of these key problems we are facing, we need to look at the resource base. In 1988, DOE published an assessment of the resource base that said the technically recoverable base in the lower 48 states was over 1,000 trillion cubic feet.

In addition, over half of that, about 580 trillion cubic feet, were recoverable at $3 per Tcf or less. So it is clear that there is no gas resource limitation that would preclude an expanded role for gas. What is lacking is really a viable DOE research program funded jointly with the gas industry.

The DOE Gas Research Program Implementation Plan which was put out last April, lays out a program that was coordinated and critiqued with the natural gas industry calling for about $22 million a year. The second year of the plan, which is what we are proposing Congress fund, would provide $7.1 million for R&D on conventional gas resources, primarily secondary gas recovery and data base activities, $10.6 million on unconventional gas, primarily in the Devonian Shales and Tight Sands, and $4.5 million on Speculative Resources. Funding of $24 million in year three and about $25.5 million in year is required. We urge the committee to seriously consider funding that plan.

In accordance with the committee's direction, you asked us to look at cooperative R&D ventures. GRI endorses the approach for field-based activities, those that have proceeded beyond proof of concept, and are getting closer to technical and commercial feasibility, it is realistic to look at getting significant cost sharing from industry from those activities.

For example, we currently have a cooperative R&D effort with DOE and the Bureau of Economic Geology at the University of Texas, looking at secondary gas recovery. This is a three-year, $22.25 million program. It is proceeding on schedule. It proves that cooperative R&D ventures can work when you get to the proper phase of the R&D development.

However, we don't think that a rigid policy adopting specific guidelines for all phases of the technology is good policy. As a general rule, the closer you get to technical and commercial feasibility, the more cost-sharing you should expect. By the time a technology is ready to be demonstrated, essentially at commercial scale and field-based activity, then I think you should expect industry to put in significant amounts of cofunding.

It is not reasonable, however, to expect private sector cost sharing in the very early stages of research, before the technical feasibility of a concept is proven in the laboratory. This is long-term, high-risk R&D. There may never be a product, there may never be payback to the industrial sector. Therefore, Government funding for the basic research elements is appropriate and should be encouraged.

In looking at cooperative R&D ventures there are four specific ones GRI would propose to co-fund 50-50 with the fossil energy program this year. One is the hydraulic fracturing test site. This would be a four-year program requiring $1.5 million each year from DOE and GRI to get basic data on hydraulic fracturing primarily for tight formations. Another one would be an improved fracture treatment design, requiring the construction of a fracturing fluid characterization facility. Again, this would take about $1.5 million each from DOE and GRI over four years.

A third program would be a natural gas atlas series. These essentially are detailed geological road maps to known fields in the U.S. We propose to develop these jointly with DOE, requiring about $1 million a year from each one of us over the next four years. The first one has been finished. It is a gas atlas of Texas. Over 1,600 copies have already been requested and sold to producers in the State of Texas. We want to do similar ones for the other producing regions in this country to help the independent producers have a better detailed geological road map especially if we go into significant in-field drilling and secondary gas recovery.

The fourth program we proposed is in horizontal drilling. This would really be to provide gas producers with accurate information on how horizontal drilling works in Devonian Shale. Again, this would take about $1 million a year over the next four years to be matched by the gas industry.

In summary, Mr. Chairman, an expanded cooperative R&D program of natural gas supply allowing true partnership of DOE and the gas industry is required if natural gas is to expand to meet its potential to help solve some of our key environmental problems and reduce our reliance on insecure oil imports.

Our current DOE budget does not do this. Congress should provide $23.8 million in DOE's fiscal year 1992 fossil energy program to fund the second year of the natural gas plan as developed by the Department, and as proposed in the National Energy Strategy.

The gas industry, through GRI, is prepared to co-fund field test activities and technology transfer activities on a 50-50 basis.

That completes my statement, and I would be glad to answer any questions.

[The prepared statement of Mr. Webb follows:]

## STATEMENT OF DAVID O. WEBB
SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS
GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
MARCH 14, 1991

Madame Chairman and Members of the Committee, I appreciate the opportunity to testify today to present Gas Research Institute's (GRI) FY 1992 budget recommendation of $23.8 million for the Department of Energy's (DOE) natural gas supply research program. This recommendation is only one part of a $214.9 million budget that the gas industry is proposing for all gas-related research within the DOE budget. A table detailing the $214.9 million recommendation is attached at the end of my testimony as Exhibit 2. Since GRI cofunds research with DOE in other elements of the Fossil Energy Program, I have also included as Exhibit 1 funding recommendations and details about these other research efforts. I urge the Committee to consider the total gas industry recommendation for gas-related R&D in DOE.

Today, as you requested, I will present detailed testimony on GRI's budget recommendation of $23.8 million for natural gas supply research in DOE's Fossil Energy Program. Within this recommendation, specific programmatic research funding recommendations are as follows:

| | |
|---|---|
| Eastern Devonian Shales | $ 3.0 million |
| Western Tight Sands | 5.0 million |
| Technology Transfer | 5.0 million |
| Environmental Research | 2.0 million |
| Integrated Data Base Analysis | 3.0 million |
| Subquality Gas Processing | 1.0 million |
| Speculative Resources | 1.9 million |
| Secondary Gas Recovery Economic Analysis | .5 million |
| Gas Hydrates | 1.5 million |
| Deep Sedimentary Basins | .9 million |
| TOTAL Unconventional Natural Gas | $23.8 million |

Central to this recommendation is GRI's plan to commit $52.45 million in 1992 to research in these same unconventional natural gas areas.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and finances a cooperative R&D program for the benefit of its 320 members and their customers. The R&D program is implemented through contracts with research organizations, engineering firms, universities, energy companies, and manufacturers. National energy R&D policy is a major factor influencing the R&D program since GRI cofunds and coordinates many of its research projects with DOE. GRI coordinates approximately $30 million annually in research with DOE. Therefore, even though GRI is not a government contractor and receives no federal funds, Congressional action on the proposed DOE budget has a direct impact on GRI's program.

## DOE ENERGY POLICY STATEMENTS VS. BUDGET REALITY

Three major federal and Congressional actions have occurred during the past year that indicate energy policy would encourage a significantly expanded role for natural gas. Last April DOE published its Gas Research Program Implementation Plan projecting a budget for natural gas supply in the second year of $22.2 million. In October Congress passed the Clean Air Act Amendments of 1990 setting in place actions to reduce emissions from mobile and fixed sources, thereby placing a premium on clean-burning fuels such as natural gas. Then, last month, the Administration released the National Energy Strategy (NES) that has as one of its primary goals, "Encourage the efficient production of natural gas in an environmentally sound manner." The proposed approach in NES is "Support R&D on better technologies for natural gas production . . ." The stated implementation is to be in accordance with the NES R&D framework, which emphasizes the use of joint government-industry R&D consortia with an expectation of 50% cost sharing.

NES states that the DOE Gas Research Plan will be implemented.

> The plan focuses Department efforts on (1) developing better recovery technologies for the conventional natural gas resource base and broadening efforts to recover unconventional resources, such as tight sand formations and Devonian shale; (2) improving secondary gas recovery from existing fields; and (3) more economic development of speculative gas resources, such as gas hydrates, deep gas, and abiogenic gas.

Furthermore, NES states, "These programs will complement R&D activities of the Gas Research Institute (GRI) . . ."

However, despite the NES policy statement of support for implementing the DOE Gas Research Plan, the FY 1992 budget request for natural gas supply research is only $8 million, not the $22.2 million required in the Plan. GRI stands ready to work with DOE to implement the Plan and has budgeted $52 million toward this goal. Congress should fund the DOE Plan so a true joint government/gas industry program can be implemented to allow gas to fulfill its potential to reduce oil imports and to reduce environmental problems.

One additional indication of the serious imbalance between the DOE policy initiatives and the FY 1992 budget request is the comparison of electric versus gas R&D. DOE proposes $1.69 billion for electric R&D and only $78.3 million for all gas-related R&D, a ratio of 21.6 to 1 (Table 1). This budget is so biased toward electricity that the budget distorts the normal working of the marketplace. Congress needs to restore a workable balance by funding the gas industry's recommended $214.9 million gas-related R&D program in DOE's FY 1992 budget.

### Table 1
### Electric vs. Gas R&D Funding
### FY 1992 DOE Budget Request
### ($ Millions)

| Electric | |
|---|---|
| Nuclear Energy | $ 431.8 |
| Fusion Energy | 337.1 |
| Nuclear Physics | 342.4 |
| Electric Energy Systems and Storage | 38.0 |
| Geothermal | 20.2 |
| Hydroelectric Systems | 1.0 |
| Solar Thermal | 20.0 |
| Photovoltaics | 50.8 |
| Wind Energy | 13.9 |
| Clean Coal Technologies | 315.0 |
| Combustion Systems | 18.7 |
| ARTD | 21.4 |
| Control Technology and Coal Preparation | 22.5 |
| Cogeneration | 3.3 |
| Electric Drives | .5 |
| Electric and Hybrid Propulsion Development | 41.6 |
| Utility Sector | 6.8 |
| | $1,685.0 |

| Gas | |
|---|---|
| ARTD | $ 1.0 |
| Combustion Systems | .5 |
| Fuel Cells | 22.4 |
| Surface Coal Gasification | 5.4 |
| Unconventional Gas Recovery | 8.0 |
| Advanced Extraction and Process Technology | 3.0 |
| Building Sector | 7.5 |
| Industrial Sector | 9.2 |
| Transportation Sector | 12.5 |
| Biofuels | 6.3 |
| Geopressured Research | 2.5 |
| | $78.3 |

Electric to Gas Ratio 21.5:1

Furthermore, natural gas supplied approximately 23 percent of U.S. energy needs in 1989 and is projected to supply 21 percent in 2010. Yet DOE's R&D budget allocates less than 1 percent to natural gas supply R&D and less than 3 percent for all gas-related R&D in FY 1992 (Exhibits 3 and 4). This is another indication of the serious underfunding of gas R&D in DOE's FY 1992 budget. Regardless of the frame of reference, DOE's budget request for energy R&D does not support NES, is nearly totally biased toward electricity, and is out of balance with energy use in the United States. This is not sound energy policy.

## NATURAL GAS--THE FUEL FOR THE 90s

As an abundant domestic resource, natural gas can play a significant role in the nation's energy balance and has the potential to make a meaningful contribution in cleaning up the environment.

Since natural gas currently accounts for nearly one-fourth of the energy used in the United States, it is important that adequate supplies are available at competitive prices to meet today's demand, as well as to provide for the additional demand which could result as the nation addresses the questions of clean air and global warming. Natural gas is our nation's cleanest burning fossil fuel. Its combustion emits virtually no particulates or sulfur oxides, and it produces far lower emissions of ozone precursors, carbon monoxide, and other pollutants.

To assess whether it is feasible to increase gas use as one key element of national energy policy, we need to consider current natural gas demand and to examine the gas resource base. Estimated consumption of natural gas in 1989 was 19.4 quads. Current production is running slightly above that at 19.6 quads annually.

Technological advancements will continue to add to the capability to recover natural gas. This is where the federal government needs to ensure a stable research and development program and to involve the natural gas industry in order to be prepared to meet the nation's growing need for a stable domestic energy resource.

## Natural Gas Resource Base Is Huge

A 1988 Department of Energy Study, An Assessment of the Natural Gas Resource Base of the United States, states that a technically recoverable resource base of 1059 trillion cubic feet (Tcf) of natural gas exists in the lower-48 states (see Table 2). The recovery of approximately one-half of this gas in the resources category requires discovery and development of new technology, some using improved understanding of reservoir geometry. Based on the study, 800 Tcf exist or are estimated to exist in conventional reservoirs. More than half of the total resources evaluated in the lower-48 states, 583 Tcf of gas, is judged economically recoverable at less than $3/Mcf (wellhead prices, 1987$). An additional 174 Tcf of gas is judged economically recoverable in a price range of $3 to $5/Mcf.

Table 2
Comparison of Recent Estimates of
U.S. Natural Gas Resources
(Tcf)

| | DOE | PGC | GRI |
|---|---|---|---|
| Lower-48 Proven Reserves | 159 | 154 | 159 |
| Undiscovered Resources | 900 | 678 | 978 |
| Total Lower-48 | 1,059 | 832 | 1,127 |
| Alaska | 129 | 152 | N/A |
| **Total U.S.** | **1,182** | **984** | **N/A** |

It is clear there is no gas resource limitation that would preclude an expanded role for gas in the U.S. energy economy. The uncertainties of gas deliverability are not resource limitations. Rather, they are the pace of technological innovation and of new investment that will be necessary to sustain the levels of gas production needed in the future.

The next question, then, is, "Can technology make a difference in the gas resource base?" The gas resource base accessible to U.S gas users under current industry practices generally reflects the 1970s perceptions of that resource base. Under current-practice (base technology), U.S. gas production was sustained primarily by the discovery of new fields and reserve appreciation in known fields using traditional development practices. Less conventional sources (e.g., Devonian shale, tight sands, coalbed methane) played a very minor role in industry activity. These sources were generally considered to require very high prices and/or new technology.

In the 1980s, new initiatives began to expand the perception of the gas resource base available to the U.S. gas user. New technologies and practices (advanced technology) developed in the 1980s or expected in the future indicate that less conventional gas sources can play a substantial role in future gas supply, even without high prices.

Table 3 categorizes the supply sources in the 1991 GRI Baseline Projection by current practice or new initiatives. Current practice supply declines through the Projection period. The increased gas supply in the 1991 Projection arises from the growing role of new initiatives in the U.S. gas supply picture.

Table 3
Gas Supply Trends
(Quads)

| | Actual 1989 | 1995 | 2000 | 2010 |
|---|---|---|---|---|
| Current Practice | | | | |
| o Domestic Production | 18.0 | 15.8 | 15.7 | 14.1 |
| o Canadian Imports | 1.3 | 1.8 | 2.0 | 1.5 |
| o LNG Imports | 0.1 | 0.5 | 0.8 | 0.8 |
| o Supplemental Sources* | 0.2 | 0.3 | 0.3 | 0.3 |
| Total | **19.6** | **18.4** | **18.8** | **16.7** |
| **New Initiatives** | | | | |
| o Lower-48 Advanced Technology | 0.0 | 1.3 | 2.9 | 5.4 |
| o Alaskan Pipeline | 0.0 | 0.0 | 0.0 | 1.3 |
| o Canadian Frontier | 0.0 | 0.0 | 0.0 | 0.3 |
| o Other Imports | 0.0 | 0.0 | 0.0 | 0.2 |
| o Synthetics | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 0.0 | 1.3 | 2.9 | 7.2 |
| Total Supply | 19.6 | 19.7 | 21.7 | 23.9 |

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*Supplements include "other" gas (SNG from petroleum, propane-air, and refinery gas) and coal gas.

The lower part of Table 3 presents the portfolio of new initiatives sources. The incremental lower-48 gas production resulting from advanced technology provides a little more than 13 percent of U.S. gas supply by 2000 and 22.5 percent by 2010. The advanced technology production is from Devonian shale, tight sands, coal seams, and watered-out reservoirs.

The advanced technology production does not include any contribution from improved gas recovery from high-permeability gas reservoirs using more intensive drilling. The recent DOE gas resource study indicated that with advanced technology, the resource exceeds 120 Tcf at $3/Mcf. GRI has begun its own analysis of this resource potential, and the first basin analysis has been completed. GRI's study concludes that with improved technology almost 7 Tcf of gas can be recovered from the producing sections in the San Juan Basin at an average levelized cost of less than $2.50/MMBtu (1988$).

The contribution of advanced technology production will depend on the pace at which the predictability and reliability of new production techniques can be demonstrated and brought into widespread (i.e., "conventional") use. GRI expects that these advanced technologies will begin to become available in the early-1990s. This will be achieved only through an expanded and directed joint DOE/gas industry near-term supply R&D program to make advanced technology available and widely applied on a timely basis.

It is clear that advanced technology is a major factor in developing a stable, economic domestic gas supply and in solving some of our environmental problems. What is needed is an aggressive federal/gas industry joint R&D effort during the next five years.

## DOE Natural Gas Research Program Implementation Plan

In April 1990, DOE released its Gas Research Program Implementation Plan. In this plan the Department acknowledged the need for further natural gas research to provide a clean, economical domestically produced energy source to meet the nation's growing energy needs. In the Plan, it was stated that, "Although only 187 Tcf of the over 1000 Tcf of technically recoverable, domestic gas is classified as 'proved reserve,' the resource base is there. The technology must be developed to find and produce it at an acceptable cost. The major thrust of the DOE implementation program in natural gas is to catalyze and accelerate the development of that technology." The Plan identifies needed research within three time frames as follows:

Near Term. (1) Consolidation of data bases; (2) compilation of gas "atlases"; (3) development of technologies to extract greater percentage of gas remaining in mature fields; (4) restoration of production from stripper wells; (5) economic processing of low-quality gas; (6) improved directional drilling technology.

Mid Term. (1) Focus on tight gas resources--sandstones, shales, and coalbed; (2) development of cost-effective methods for increasing size and gas flow capability of the fracture system.

Long Term. Development of technologies for recovering gas from deep sediments and gas hydrates in unexplored or under-explored zones and in new classes of reservoirs.

The DOE Research Plan outlines a base case budget scenario to implement the Plan as follows:

**Table 4**
**DOE Budget Scenario**
**Unconventional Natural Gas**
**Base Case***
**($ Millions)**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Conventional Gas | 4.0 | 7.1 | 6.9 | 6.9 | 4.8 |
| Unconventional Gas | 9.9 | 10.6 | 10.6 | 11.5 | 11.7 |
| Speculative Resources | 1.9 | 4.5 | 6.5 | 7.0 | 6.2 |
| TOTAL | 15.8 | 22.2 | 24.0 | 25.4 | 22.7 |

Average for 5-year plan = 22.02

*A detailed breakout of the Base Case is found in Exhibit 5 at the end of the document.

The Department developed a base case for funding requiring $22.2 million in Year 2 of the Plan. The funding breakout included $7.1 million for R&D on conventional gas; $10.6 million, on unconventional gas; and $4.5 million, on speculative resources. Funding of $24.0 million in Year 3 and $25.4 million in Year 4 is required to implement the Plan.

The Administration noted this plan will be implemented in accordance with the NES R&D framework, which emphasizes that use of joint government-industry R&D consortia. GRI urges the Committee to fund the second year of the DOE Natural Gas Plan and stipulate that field-based activities totaling approximately $10 million be 50-50 cost shared with GRI and the gas industry. GRI has a budget in 1992 of $48.95 million devoted to these same research areas and is committed to cofunding activities in cooperative R&D ventures.

Congress provided $15.9 million in FY 1991 to fund the first year of the DOE Natural Gas Plan. Funding of $22.2 million is required to fund the second year.

## COOPERATIVE AGREEMENTS

The Department's preferred approach to research and development is through cooperative agreements with industry cofunding. GRI endorses this approach for field based research activities and is ready to accept the challenge to cofund cooperative R&D ventures with the Department of Energy. Under the cooperative R&D venture concept, once the project scope of work and cost parameters have been negotiated, the government relinquishes daily management control in exchange for 50 percent cofunding from private partners. Through the industry's willingness to invest its own resources (at least 50 percent of the project funding), the government is paying half the cost of a project that it judges to be in the public interest.

As an example, GRI is currently providing the dominant share of private sector funding to one of the first DOE/private sector cooperative R&D ventures under a pilot program established by DOE's Fossil Energy Program. In September 1988, DOE, GRI, and the Bureau of Economic Geology (BEG) at the University of Texas agreed to cofund a cooperative R&D venture on secondary gas recovery. The purpose of the three-year, $22.25 million project is to develop and test new technologies and methods with near-term potential to identify and recover bypassed gas, trapped gas, and gas in deeper horizons of existing gas fields.

Initial emphasis will be placed on formations near the Texas Gulf Coast, which contain some of the most productive gas fields in the nation. DOE has estimated that about 120 Tcf of additional natural gas may be recovered by secondary gas recovery in known gas fields in the lower-48 states. Economic recovery of these additional resources obviously will have a major impact on the U.S. energy future.

In GRI's experience, cooperative agreements show many advantages beside the obvious one of leveraging resources. These advantages include an increase in information from industry and government teams; complementary abilities; rapid transfer of technology; bridging the gap between public and private funding; and finally, it works.

In response to the Committee's question regarding the use of cost-shared contracts, GRI proposes it is not good policy to adopt rigid guidelines for all phases of technology development. As a general rule, the closer a technology gets to technical and commercial feasibility, the more cost sharing should be expected from the private sector. This general rule should apply regardless of the size of the private sector contractor since the ultimate goal must be commercialization. By the time a technology is ready to be demonstrated at an actual field site, it is appropriate for DOE to seek 50 percent cost sharing from the private sector in exchange for daily management of the contract by the private sector partner. This arrangement is a very cost-effective method GRI has used to accomplish technology transfer.

It is not reasonable, however, to expect private sector cost sharing in the very early stages of research before the technical feasibility of a concept is proven in the laboratory. These projects involve long-term, high-risk R&D and may not result in any payback to a private sector partner.

## Future Cooperative Ventures

GRI is proposing to fund with DOE cooperative R&D ventures that can accelerate technology transfer in the unconventional natural gas areas. With $5 million funding from DOE combined with $5 million from GRI, several critical technology transfer initiatives can be accomplished.

1. Hydraulic Fracture Test Site--The principal objective of the test site will be to provide a field laboratory for proof-of-concept tests of techniques to improve hydraulic stimulation of fractures in tight gas sandstones. It will also provide a convenient mechanism for the execution of multi-disciplinary research tasks to investigate the mechanics of hydraulic fracturing. DOE will provide approximately one-half of the $12 million in total estimated costs with the balance to be provided by the gas industry. It is recommended that DOE provide $1.5 million per year for four years to this project.

2. Improved Fracture Treatment Designs--Characterizing hydraulic fluids under in situ conditions will ultimately result in increased recovery of gas from any reservoir that is hydraulically fractured to stimulate production. In order to accomplish this objective, the design and construction of a permanent, large-scale Fracturing Fluid Characterization Facility is necessary. The benefits resulting from this research relate directly to the costs of implementing fracture treatments and the increase in reservoir deliverability expected due to the reservoir stimulation. Lack of knowledge of fracture fluid behavior or reasons for the behavior causes the industry to overdesign the volumes and properties (e.g. viscosity) of the fluid systems and to misinterpret the effects of injected fluids on reservoir flow capacity, as well as the placement of proppant in the fracture itself. Treatment overdesign is generally done as an insurance against poor treatment performance rather then from trying to optimize expected reservoir performance.

   The information, hardware, and analytical tools that will evolve from this project will allow the industry to lower fracture stimulation costs in many instances by reducing fluid volume costs, horsepower charges, and gel additive costs. In other cases, increased knowledge of fracturing fluid behavior may result in an increased job size; however, with the improved understanding of fluid/fracture/proppant interactions, it will be possible to quantify the economic benefits of the increased job size. These benefits will accrue to independent producers as well as majors, since the benefit of more efficient fracture treatments is universally applicable to any formation which is hydraulically fractured. It is recommended that DOE provide $1.5 million per day for four years to this project.

3. Natural Gas Atlas Series--To provide gas producers with information needed to more efficiently develop reservoirs, to extend field limits, and to better assess opportunities for intrafield exploration and development, DOE funds would accelerate and expand the GRI natural gas atlas series. The atlases will serve as a standard reference that accurately portrays the nature and distribution of gas resources. The project will include regional atlases for the Appalachian, California, Rocky Mountains, central and Eastern Gulf Coast, Midcontinent and Offshore (Gulf Coast) regions. An atlas for the State of Texas has already been published. The state geological surveys will synthesize the basic data for gas reservoirs and develop plays for their respective states. The geological information gathered and displayed will include definition of a variety of

environments of deposition, diagenetic controls and trapping styles for gas reservoirs. It is recommended that DOE provide $1.0 million per year over the next four years.

4. Data Analysis and Dissemination--A joint program would provide gas producers with accurate information on the applicability of horizontal drilling technology in Devonian shales through the implementation of technology development effort to develop and analyze horizontal and well data. Additionally, the joint program will facilitate the development and dissemination data on preferred completion techniques. It is recommended that DOE provide $1.0 million per year over the next four years.

## NATURAL GAS SUPPLY ENHANCEMENT--UNCONVENTIONAL SOURCES

Eastern Devonian Shales: In general, two major factors constrain present-day exploitation of this resource: (1) the inability to predict with confidence the gas production rates that will be obtained in wells drilled outside historical production areas, and (2) the inconsistent response of formations to currently employed stimulation practices.

Barriers to economic production of natural gas from Devonian shales include:

- Inadequate understanding of factors that control the flow of gas from Devonian shale formations to the wellbore;
- Lack of effective exploration rationales to identify geographic areas and stratigraphic zones with highest production potential;
- The need for improved diagnostic methods to assess the potential of productive zones;
- Inadequate understanding of shale gas reservoir dynamics; and
- Lack of generally effective stimulation techniques.

Economic exploitation of the full resources hinges on development of improved techniques and technologies for overcoming these limiting factors. A recommendation of $3 million would allow the Department of Energy to conduct a program addressing these issues. GRI has a budget of $4.3 million for research in eastern Devonian shales. GRI believes DOE should fund Devonian shale R&D at a level of $3 million per year over the next three years.

Western Tight Sands: Gas-bearing tight sands occur in the form of blanket-type and lenticular formations. In both types, the effects of a variety of interdependent parameters are still unknown, and consequently, the gas recovery rate and active reservoir life for a given field remain uncertain. To permit low-cost exploitation of the full potential of the tight sands resource base, the following specific technological issues need to be addressed:

- Determine the relationship between geologic and engineering parameters;

- Further characterize tight sands gas reservoirs and improve resource estimates;
- Identify the parameters critical to formation evaluation and gas production;
- Understand more clearly the mechanisms of hydraulic fracture propagation and control;
- Diagnose fracture shape and downhole conditions using surface parameters;
- Provide real-time fracture treatment design changes; and
- Apply advanced technologies to presently noncommercial areas.

A total recommendation of $5 million per year for the next three years would allow the Department of Energy to address these issues. GRI's budget for research in tight sands is $16.1 million.

## SUMMARY

An expanded cooperative R&D program requiring the partnership of DOE and the gas industry is required if natural gas is to fulfill its potential to help solve the nation's environmental problems and reduce insecure oil imports. The current DOE budget request for natural gas does not provide adequate funding for such a program. Congress should provide $23.8 million in DOE's FY 1992 Fossil Energy Program to fund the second year of the Natural Gas Plan as proposed in NES.

## Exhibit 1
## Gas-Related Research Recommendations for DOE FY 1992 Fossil Energy and Conservation Programs
## ($ Millions)

| | FY 1992 Gas Industry Recommendation for DOE's Budget | GRI's Planned Budget 1992* | Estimated Cofunding From Industry 1992 |
|---|---|---|---|
| **Fossil Energy** | | | |
| ARTD (Gas-Related) | $ 6.0 | $ 10.45 | $ 0.0 |
| Fuel Cells (Gas-Related) | 62.0 | 4.10 | 3.3 |
| Coal Gasification | 8.5 | 0.00 | 0.0 |
| Combustion Systems/Emission Control | 17.8 | 6.15 | 4.7 |
| Gas Cofiring/Reburn | 8.5 | 5.20 | 1.0 |
| Heat Engines (Gas-Fueled) | 6.9 | 5.40 | 6.5 |
| Unconventional Natural Gas | 23.8 | 52.45** | 15.4 |
| **Fossil Energy Total** | $133.5 | $ 83.75 | $30.9 |

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*Preliminary; not FERC-approved.

**Includes $4.86 million for geosciences.

Exhibit 1, Continued

## Other DOE Fossil Energy FY 1992 Budget Recommendations

Heat Engines/Gas Turbines. Converting the chemical energy in fossil fuels to electricity and shaft power is a major component of the overall U.S. energy picture. This type of energy conversion is accomplished with a range of processes and equipment that includes large-scale electric utility and onsite industrial power plants and smaller industrial and commercial cogeneration systems.

Natural-gas-fueled power generation systems can provide gas consumers with cost-effective alternatives to coal- or petroleum-fueled technologies while helping to ensure compliance with environmental regulations. Gas-fueled systems in this category include engine-driven cogeneration, machine drive, and electric power generation systems. R&D issues, depending on the type of system, include fuel efficiency, first cost, emission control, durability, reliability, extension recovery, connection to the electric utility grid, flexibility to respond to changing thermal and electric power demands, safety, and integration of advanced controls and diagnostic systems.

Heat engines can contribute positively to the environment and to energy conservation. R&D to develop high-efficiency natural-gas-powered turbines in a wide array of sizes for electric generation should include steam-injected gas turbines (STIG), intercooled steam-injected gas turbines (ISTIG), and chemically recuperated reheat gas turbines (IR-CRGT), as well as low-emissions gas turbine retrofit equipment that helps avoid the costly alternative of post-combustion emission control.

The ISTIGs, in particular, are approximately 50 percent more efficient than conventional power plants, cost half as much as new coal or nuclear plants, and can help solve the nation's air pollution problems. Conceptual studies of the IR-CRGT turbine indicate that high efficiencies and very low emissions can be achieved using this technology. In this technology, some of the natural gas fuel is reformed using heat from the turbine exhaust, thus increasing system efficiency to levels as high as 60 percent. The presence of hydrogen in the fuel can decrease $NO_x$ to below 5 ppm. The principal area for research is the development of an efficient reformer that operates at temperatures low enough for effective heat recovery from the turbine exhaust.

The need also exists for RD&D efforts aimed at other engines. Such efforts must adapt the latest liquid-fueled engine technology to dedicated natural gas engines that produce shaft power for water pumping, gas compression, and various industrial and commercial applications. The necessary RD&D includes increasing efficiency and power output through improved combustion techniques and reducing emissions while preserving performance through advanced controls, optimized components, and innovative exhaust treatment techniques. A total of $6.9 million is recommended for each of the next three years to develop these technologies.

Molten Carbonate Fuel Cells. A fuel cell uses natural gas in an electrochemical process to produce electricity and heat. This is accomplished with very high overall energy efficiency, good reliability, low noise, and virtually no pollutants.

The development of a carbonate fuel cell system has numerous technical issues that must be addressed and resolved prior to commercial introduction. The major issues fall into two categories: system development and integration; and stack technology and scale-up.

System studies and conceptual designs have indicated feasibility of standard engineering subsystems and economic competitiveness with alternate technologies. Natural-gas-fueled power plant designs in the 1 to 20 MW capacity range are estimated to have electric generation efficiencies in the 50 to 55 percent HHV range. Mature market power plant costs of <$1,000/kW are expected, and market entry targets of $2000/kW have been set. One critical assumption of these cost estimates is the ability to cost-effectively manufacture the cell stacks. The other critical issue to achieving these projections and targets is the development of a system-level technology. The initial step is the integration of a sub-scale breadboard system which incorporates all the components of a power plant and verifies their integration and operation through testing. The critical technical issue is the ability to design and manufacture a cost-effective, durable, safe, and reliable system which meets the application requirements. Central to this issue are component selections, integration approaches, control strategies and procedures, and cost-effective fabrication and construction.

Central to the system verification question is the availability of the technology base required to manufacture low-cost carbonate fuel cell stacks with long-term performance and reliability. The technology base efforts of the 1980s have enabled the developers to begin scale-up efforts to full-area and full-height cell stacks.

Major R&D efforts requiring $38.5 million of DOE funding in FY 1992 and FY 1993 are needed to fund the existing fuel cell development teams under contract to DOE to develop cell fabrication technology and durability before detailed molten carbonate fuel cell system development can be undertaken. Major industry cofunding totaling approximately $100 million over the next four years is being provided by GRI, M-C Powerteam, EPRI, and natural gas utilities. GRI plans $20 million of cofunding. Last year DOE signed a $26 million, three-year contract with the M-C Powerteam industrial team to develop a prototype molten carbonate fuel cell. Total FY 1992 DOE funding for the second year of the M-C technology is $18.5 million.

Solid Oxide Fuel Cells. Solid oxide fuel cell technology is promising due to its potential for high-power-density cell stacks; its solid-state construction, which eliminates the liquid electrolyte; and its potential as a simpler, less-expensive system. Major R&D efforts are needed, however, on cell fabrication technology and durability before detailed solid oxide fuel cell system development can be undertaken. Annual DOE funding of $8 million is required in FY 1992, FY 1993, and FY 1994.

Exhibit 2

## DOE FY 1991 & 1992 Gas-Related Budget
($ Millions)

|  | FY 1990 Congress'l. Approp. | FY 1991 Congress'l. Approp. | FY 1992 DOE Request | FY 1992 Gas Industry Recomm'n. |
|---|---|---|---|---|
| Stationary Emissions/Efficiency |  |  |  |  |
| Combustion--System/Emission Control | 0.0 | 0.0 | 0.5 | 17.8 |
| Conservation (Cooling & Ind'l. Processes) | 25.4 | 25.1 | 16.7 | 36.8 |
| Heat Engines | 0.0 | 0.0 | 0.0 | 6.9 |
| Coal & Waste Cofiring/Reburn | 2.5 | 0.0 | 0.0 | 8.5 |
| ARTD | 4.7 | 3.9 | 1.0 | 6.0 |
| Transportation Fuel/Emissions Solutions |  |  |  |  |
| Natural Gas Vehicles | 2.5 | 5.5 | 12.5 | 27.0 |
| Electrochemical Energy Conversion |  |  |  |  |
| Fuel Cells | 30.1 | 36.0 | 22.4 | 62.0 |
| Subtotal | 65.2 | 70.5 | 53.1 | 165.0 |
| Gas Supply Enhancement |  |  |  |  |
| Unconventional Natural Gas | 14.6 | 16.0 | 8.0 | 23.8 |
| Surface Coal Gasification | 23.7 | 15.1 | 5.4 | 8.5 |
| Geopressured Resources | 6.0 | 6.0 | 2.5 | 9.6 |
| Biofuels | 8.6 | 4.5 | 6.3 | 8.0 |
| Underground Coal Gasification | 0.8 | 0.8 | 0.0 | 0.0 |
| Geosciences | 4.0 | 4.6 | 3.0 | * |
| Subtotal | 57.7 | 47.0 | 25.2 | 49.9 |
| TOTAL | $122.9 | $117.5 | $78.3 | $214.9 |

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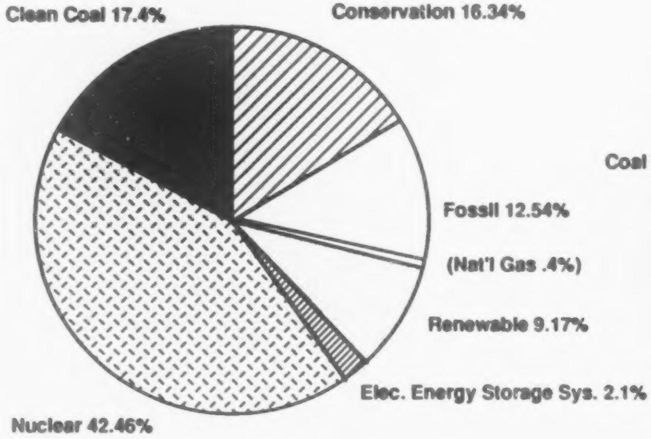
*While the gas industry is supporting geosciences as a concept, the gas industry is not supporting a specific line-item funding level. The industry is, however, supporting a funding level of $10 million for gas-related geoscience work that is included in other line items, e.g., Advanced Extraction and Process Technology and Unconventional Natural Gas.

Exhibit 3

# DOE R&D Program is Out of Balance with Current Energy Needs

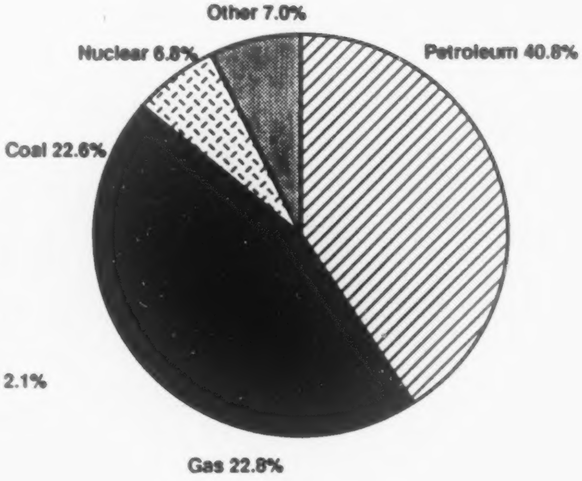
1992 DOE Energy R&D Request



Total DOE Energy R&D = $1,810.1 Million

(Does Not Include Power Marketing Administration)

1989 Consumption*



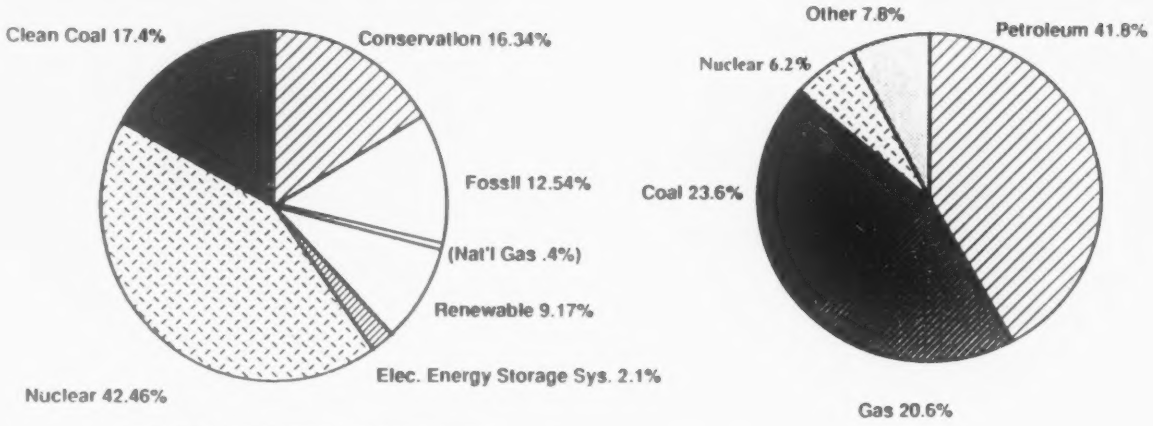
*1991 GRI Baseline Projection of U.S. Energy Supply & Demand to 2010

Exhibit 4

## DOE R&D Program is Out of Balance with Future Energy Needs

1992 DOE Energy R&D Request

2010 Consumption*



Total DOE Energy R&D = $1,810.1 Million

(Does Not Include Power
Marketing Administration)

*1991 GRI Baseline Projection of U.S. Energy Supply & Demand to 2010

Exhibit 5

## BASE CASE BUDGET
(Dollars in Thousands)

| | FY 1992 | FY 1993 | FY 1994 | FY 1995 | FY 1996 |
|---|---|---|---|---|---|
| **CONVENTIONAL GAS** | | | | | |
| Data Synthesis | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 |
| Enhanced Gas Recovery | 1,000 | 3,000 | 3,000 | 2,600 | 500 |
| Low-Quality Gas Upgrading | 200 | 300 | 100 | 500 | 500 |
| Gas System Analysis | 300 | 300 | 300 | 300 | 300 |
| Environmental Research[1] | 0 | 1,000 | 1,000 | 1,000 | 1,000 |
| Subtotal | 4,000 | 7,100 | 6,900 | 6,900 | 4,800 |
| **UNCONVENTIONAL GAS** | | | | | |
| Tight Formation Gas - Eastern | | | | | |
| Resource Characterization | 1,200 | 1,200 | 700 | 700 | 700 |
| Production Technology | 2,700 | 2,700 | 3,300 | 4,000 | 4,500 |
| Supporting Research | 900 | 1,100 | 1,000 | 1,100 | 800 |
| Subtotal | 4,800 | 5,000 | 5,000 | 5,800 | 6,000 |
| Tight Formation Gas - Western | | | | | |
| Resource Characterization | 600 | 600 | 600 | 600 | 600 |
| Production Technology | 4,000 | 4,500 | 4,500 | 4,600 | 4,600 |
| Supporting Research | 500 | 500 | 500 | 500 | 500 |
| Subtotal | 5,100 | 5,600 | 5,600 | 5,700 | 5,700 |
| **SPECULATIVE GAS** | | | | | |
| Deep Sedimentary Basins | | | | | |
| Basin/Rock Properties | 500 | 500 | 550 | 600 | 200 |
| Wells of Opportunity | -- | -- | 1,000 | 1,000 | 1,000 |
| Gas Hydrates | | | | | |
| Resource Assessment | 0 | 1,300 | 1,450 | 1,600 | 1,200 |
| Production Tech. | 0 | 500 | 1,500 | 1,500 | 1,500 |
| Seismically Opaque Zones | | | | | |
| Ident./Ranking | 300 | 300 | -- | -- | -- |
| Field Studies | 300 | 300 | 600 | 600 | 600 |
| Eval./Explor. Techniques | 200 | 600 | 600 | 700 | 700 |
| New Play Concepts | | | | | |
| Identification/Ranking | 400 | 400 | -- | -- | -- |
| Field Studies | 200 | 600 | 800 | 1,000 | 1,000 |
| Subtotal | 1,900 | 4,500 | 6,500 | 7,000 | 6,200 |
| TOTAL | 15,800 | 22,200 | 24,000 | 25,400 | 22,700 |

*Average = 22,020*

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[1] The first year of environmental research is devoted to determining and defining research needs. The oil program is currently conducting crosscutting oil and gas environmental research.

Mr. STALLINGS. Thank you, Mr. Webb. We appreciate those comments.

Dr. Lee.

## STATEMENT OF DR. BERNARD S. LEE, PRESIDENT, INSTITUTE OF GAS TECHNOLOGY

Dr. LEE. Thank you, Mr. Chairman and members of the subcommittee.

I am Bernard Lee, President of the Institute of Gas Technology in Chicago. IGT is an organization dedicated to performing energy research and development, and providing educational programs in energy.

In 1979, IGT published a study on the externalities of oil import. Even though it is 12 years ago, the results are even more relevant today. I recall for you in the 1979 study that with oil prices of $20 a barrel, reducing imports by only 500,000 barrels a day will lead to a benefit of $22 per barrel of benefits to society, in terms of savings, trade deficits, improved employment, and all the societal costs, not even counting the cost of military protection.

That is $22 over and above the $20 of oil you will save. That's more than a two-to-one benefit to society. Today, of course, we know what happened in the Persian Gulf, and the military costs involved to protect us and help reduce oil imports would at least add another $20 per barrel, for a three-to-one benefit to society. Now that the war has ended, we all know the oil probably will flow again, and people have a tendency to forget that energy security is an overriding issue we must consider.

Congress must not forget the energy security issue, and must begin to internalize this tremendous externality called energy security.

Natural gas has a key and growing role in the Nation's energy mix. One, it has abundant domestic resources. Two, it is environmentally clean. Three, it has an in-place infrastructure that distributes the gas nationwide. However, we need Federal R&D support on both fronts, both fronts meaning the supply front as well as the utilization front.

On the supply side, we need support for advanced technology to convert resource into production and do so economically. On the utilization side, we need R&D support from the Federal sector to develop high efficiency, low polluting technologies that make it possible for us to utilize gas fully.

IGT, for fiscal year 1992, supports the gas industry's energy research package of $215 million, most of which belong to this subcommittee's jurisdiction. I will not go into the details, because the detail of the programs is presented in the testimony.

The reason we are looking to Congress to take strong action in R&D is that the externalities borne by society as a whole must be internalized. I can give you one good example of Congressional action, of internalizing externalities, and that is the passage of the Clean Air Act last year. That is a big step in internalizing the environmental externalities. We should do the same in energy utilization and supply.

Congress, by mandating its wishes through the Clean Air Act, injected itself into the free market to help society absorb internal costs for the long-term good of society. Likewise, Congress should lead society in absorbing the external costs of developing energy resources and energy-efficient technologies for the long-term stability and well-being of our Nation.

We must act to protect the long-term and we must maintain a balanced energy option agenda and provide sustained funding to get the job done. However, with budget pressure, the tendency has been to push policy towards requiring large cost sharing by the private sector, even in the early developmental stages.

It is perfectly okay and understandable to require heavy cost sharing in the final, commercializing stages. But it will be stifling for technology development to require cost sharing in the early stages. Premature requirement of cost sharing would shut out small innovative organizations like IGT, which is a not-for-profit one, has no dollars to cost share. It would also shut off small, dispersed users and manufacturers, for example, low $NO_x$ emission combustion equipment manufacturers, where the benefit to society is much greater than the benefits to the manufacturers for providing a piece of equipment.

IGT, for the record, is not at all against cost sharing. But we are against requiring cost sharing at the wrong time and at the wrong stage.

Let me provide several examples. An example of successful technology development that is recognized by all the testimony we have heard, and comments Mrs. Lloyd made at the opening, is the work we are doing on molten carbonate fuel cells. It has been transferred successfully to people who are trying to move it towards commercialization. DOE had just executed a three-year multi-million dollar contract with M–C Power where the requirement for cost sharing was 20 percent. M–C Power and its team members, in signing the contract, came up with a 30 percent cost sharing, more than meeting the DOE requirements.

As soon as the project started, DOE now plans to ask an increase, after the contract is signed, to 50 percent cost sharing, for fiscal year 1992. I think that's unreasonable.

Another example is a long-term resource, eastern oil shale. There is abundant oil in shale in the eastern part of the United States. The technology development is at an early stage. In the fiscal year 1991 appropriations bill, the requirement is to provide 40 percent cost sharing to build a process development unit. That requirement, in my judgment, is premature. At comparable stages of development, the requirement of cost sharing, if any, should be no more than 20 percent. Once you demand high cost sharing, you will kill the technology development, and once the technology dies, the resource will lie dormant.

A third example, and a final one, is in clean coal technology, where 50 percent cost sharing is required. I think that is perfectly okay. Technologies that are mature enough to enter that stage approaching commercialization should have high cost sharing. IGT has a process in coal gasification called U-GAS, and we will be providing, through our team members, an offer in the fourth round of clean coal technology, with 50 percent cost sharing.

In summary, the cost sharing requirement is a good concept, but it must be applied judiciously, on a case-by-case basis, weighing the stage of development in the overall technology chain, and must not be applied prematurely. To do so prematurely would be very damaging to the successful prosecution of R&D.

Thank you very much.

[The prepared statement of Dr. Lee follows:]

# TESTIMONY OF BERNARD S. LEE, PRESIDENT
INSTITUTE OF GAS TECHNOLOGY
before the
SUBCOMMITTEE ON ENERGY
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
March 14, 1991

Madame Chairman, I appreciate the opportunity to testify before this subcommittee. The Institute of Gas Technology (IGT) is about to begin its 50th year as an educational center and a not-for-profit research laboratory, working to develop a broad spectrum of energy and environmental technologies.

Although we were originally established as the education and research arm of the natural gas industry, we have expanded over time to include such research as coal gasification, production of oil from Eastern oil shales, the gasification of refuse derived fuels and a variety of industrial process and utility combustion technologies. We are also expanding into technologies for the clean-up or disposal of toxic and hazardous wastes. We have separate divisions in education, energy utilization and energy supply. Our most prominent technology development to date has been the development of the IMHEX[R] molten carbonate fuel cell system and the creation of the M-C Power Corporation to commercialize that technology.

My comments in this testimony regarding the proper role and timing of federal and private cost sharing will be based on IGT's experience as a relatively small, independent research entity that is not the research arm of a profit-making corporation, a university or a national laboratory. While that independent status offers some unique advantages and flexibility, it also carries unique limitations.

IGT has technologies at a broad range of technology development. We have some that are at the technology base level--small projects of relatively low cost that are the first building blocks of a new technology or process. Some of that work is on contract from a specific industrial client. Some of it is supported through IGT's own limited funds or through the support of some of IGT's member companies. We work closely with GRI and EPRI to coordinate research and leverage funds to bring technologies along. We actively seek private developers when they are available and federal funds to carry research of broad national interest or applicability that is not yet at a stage where private sector funds are available.

Madame Chairman, I commend this Subcommittee on its interest and effort in directing and stabilizing the role of the federal government in fossil energy research over the next three fiscal years. Particularly through our vast coal resources, we have literally hundreds of years of domestic energy supply available in our domestic fossil energy resources. Even with the strict environmental controls of last year's Clean Air Act, modelling projections done by the Gas Research Institute (GRI) suggest that by the year 2010 we will still be using fossil resources for 86% of our total energy consumption in this country, down only two tenths of one percent from 1989 consumption patterns. The distribution of that demand among fossil energy resources is projected to remain fairly constant over that 30-year timeframe, with roughly half of the demand supplied by oil and the remaining half equally divided between gas and coal.

In spite of that continued demand stability, the Department of Energy's proposed FY92 budget recommends cutting current levels of coal R&D by 60%, petroleum by 12% and gas by 50%. Collectively, that is a 51% cut in fossil R&D. While last year's budget agreement forces the careful evaluation of all federal spending in order to bring federal deficits under control, the Department's recommendations trouble the gas industry, and should trouble this Subcommittee as well.

We have fortunately just experienced a dramatic victory in a war in the Mideast. Although the cause of that war was a complex web of international political, economic and geographic issues, the significance of the world's reliance on Mideast oil was clearly a driving factor there. Because nearly half of this nation's demand for petroleum is satisfied by imports, we could not tolerate such a major disruption and uncertainty as the invasion of Kuwait by Iraq. To protect our interests, we were willing to put at risk a half million lives in coalition troops and billions of dollars of weapons and supplies. Political, military and economic uncertainty will prevail in that volatile part of the world far beyond the end of this fight. World oil prices and supplies will remain uncertain.

This is not the time to be cutting our efforts to develop sound energy technologies and reliable domestic energy supplies. We should, instead, be increasing our efforts. According to the base case projections in the National Energy Strategy plan, we are currently importing a net of 7.6 million barrels of oil a day, a total of nearly 3 billion barrels annually, continuing a tremendous drain on our economy. It is the key contributor to our trade deficit.

We may, however, have just seen evidence of a shift in world oil price policy. In the 1970s, market disruptions by OPEC countries caused world oil prices to soar, temporarily disrupting this country's economy because we lacked energy alternatives. When Iraq invaded Kuwait, however, oil prices temporarily jumped up but then slid back down almost to pre-invasion levels even before the end of the war and with both countries' oil production perhaps taken out of world markets for some time into the future. According to DOE, even that temporary spike in prices, however, cost U.S. consumers $21 billion more for oil than they would have otherwise spent. While the dynamics of emerging military and political alliances clearly played a major role in restoring market stability, the stability may also have reflected the awareness of both oil producers and consumers that the progress and diversity of energy research since the 1970s has made the whole world less vulnerable over the long term to oil price manipulation or supply disruption. While the value of the last fifteen years of energy research in this country cannot be specifically quantified, for every dollar we have lowered the ceiling price of world oil, we are saving nearly three billion dollars in our annual trade deficit.

While conservation efforts and renewable energy resources must play an expanded role in our energy mix, they will never be a total solution to our energy needs. The growing concern for the environmental impacts of fossil fuel usage should not cause us to abandon our tremendous resources but should, instead, cause us to increase our efforts to find cleaner, more efficient ways to use them.

The gas industry has assembled a package of recommendations for gas-related research totaling $165 million for utilization R&D and $50 million for gas supply. The utilization package covers fuel cells and other utility needs, industrial combustion technologies and support for natural gas vehicles. The supply research is divided among developing new domestic reserves, enhanced recovery of current resources and technologies for upgrading subquality supplies. In addition to my formal testimony, I am supplying this Subcommittee with information regarding parts of that industry package and other technologies that are of specific interest to IGT.

Madame Chairman, the gas industry proposals direct research toward increasing our nation's use of natural gas in our energy mix. Although natural gas is accurately regarded as the cleanest and most efficient of our fossil fuels, any national energy strategy should not be content to let those qualities be applied only to current markets and uses. Strong natural gas R&D programs can quickly and significantly expand the environmental advantages of natural gas to a broad range of utility and industrial applications. Further improvements in efficiency and emissions reductions can bring cost and environmental gains even to current natural gas uses. Just as the Clean Coal Technology program is bringing to market new, cleaner and more efficient industrial and utility applications for our nation's enormous coal reserves, strengthened natural gas R&D efforts can increase the positive contributions of this fuel as well.

As this Subcommittee surveys our fossil energy research needs, you are clearly on target in coupling that discussion with efforts to form a better framework for bringing developing technologies to commercialization.

The Administration, both in its FY92 budget proposal and in the National Energy Strategy Plan, is advocating that the key to commercializing energy technologies is to increasingly shift the burden to private sector cost-sharing, relying on market-driven forces to make development choices. While that emphasis may sound attractive from a fiscal standpoint, I would urge caution in moving too far in that direction.

Significant cost-sharing for technologies that are near commercial demonstration is understandable, but in the early stages of technology development, cost-sharing requirements stifle the development process. Such requirement is particularly damaging to creative, small organizations such as non-profit entities which, by definition, have little financial resources to offer.

The President, in his State of the Union message, praised the Congress for last year's Clean Air Act Amendments which "applied the creativity of the marketplace in the service of the environment." As you know, the approach in that bill relies on setting compliance standards and deadlines and then letting industry pick and choose among the best available choices for meeting those requirements. The timelines and "best available technology" clauses may primarily result in choices among off-the-shelf technologies. At that end of technology development, the marketplace may, in fact, work fairly well, although there is already a growing body of concern that marketplace decisions even in this example will be driven by short-term cost considerations and low-risk options, many of which may prove to not be the best long-term choices, either financially or in overall environmental impacts.

In the developmental stages of technology, however, relying on market forces may produce far less creative results. Energy R&D, by its very nature, requires long-term commitment and support from the public sector for the public good. A strong federal role in developing energy security and stability are fundamental to a sound and sustained growth economy. The benefits of such an energy policy are long-term, but can only be reaped by long-term commitment.

The difficulty in gaining private sector support for energy R&D varies throughout the spectrum of potential markets and end users. Developing efficient, low-emissions technologies for base load utility plants, for instance, has high costs and high risks, but utilities, by their nature and regulatory status, are constrained to be conservative risk-takers. Strong federal development support, followed by the demonstration phase emphasized by the Clean Coal technology program will bring significant results.

In the industrial and commercial end of energy R&D, however, many potential industrial markets are typically composed of small, dispersed users or are served by small technology manufacturers that have little or no industrial R&D program or experience of their own or little discretionary cash in their bottom line to invest in product development, testing or purchase. IGT is developing a number of highly-efficient, low-$NO_x$ combustion technologies that could provide significant cost-savings and environmental compliance for a broad range of small, energy-intensive industries that are faced with the pressures of the compliance levels and timelines of the Clean Air Act amendments, but these are markets without dominant, financially strong players. Without federal support, the energy efficiencies and emissions reductions that could be gained for these markets, keeping them in operation, may never be delivered.

As an example of successful technology development, IGT's IMHEX$^R$ molten carbonate fuel cell technology, through M-C Power, is on a winning track for commercialization and will have strong market acceptance once it gets there. To get it to the stage of commercial demonstration, however, still requires a long-term, costly, high-risk investment that needs patient, committed support. While we are fortunate to have that kind of support for this project, the DOE FY92 recommendation to increase already high cost-sharing now that the program appears very promising would clearly be counterproductive.

Another example is in energy supply research, where IGT--and this country--faces even larger hurdles. The Eastern oil shale program, for example, will someday add billions of barrels of competitively-priced domestic oil to our nation's energy supply, close to existing infrastructure for processing and transportation and close to high-demand markets. Under the current DOE program, we have made significant advances in bringing down the cost of that oil and have assembled a comprehensive research package that includes resource definition and environmental impact mitigation, but it is a project that must have a long-term commitment by Congress to see it through. Although we are making a concerted effort to secure the 40% level of cost-sharing required in the FY91 appropriations bill for the scale-up of this project, given the current developmental stage of this technology, that level of cost-sharing may, in fact, be premature and, without significantly flexibility, may prove stifling. Throughout the DOE budget, comparable resources and technologies at this stage of development are currently being asked for 20% cost-sharing or less.

Madame Chairman, I deeply appreciate this Subcommittee's effort to find a methodology for balancing the roles of the federal government and the private sector in assuming the costs of energy R&D and in ultimately choosing which technologies move forward and which get abandoned. No such single rule can apply to all technologies, and each technology must be considered in its own context. An effective methodology must rely on constant communication between the Congress, the Department of Energy, the technology developer and the ultimate end-users. Somehow in that flow it must also be dependable. Just as the Congress rightfully wants to see dependable commitment from the private sector when it is required, the private sector also needs to see dependable commitment from the government. The DOE FY92 budget proposal, for instance, suggests ratcheting cost-sharing for molten carbonate fuel cells up to 50% this year, even though we are in the middle of a three-year contract that called for 20% and for which M-C Power provided 30% cost-sharing. A higher requirement at this point would be extremely damaging.

Finally, Madame Chairman, I would offer one other note of caution about increased reliance on cost-sharing and market-driven choices for guiding federal R&D efforts. At any given point, that strategy may, in fact, be effective. The long-term problem is that it locks everything from that point forward into that single frame of reference. A number of years ago, this Subcommittee, in discussing ways to stimulate a strong academic research community that was--and still is--being drained off to private industry, made the accurate analogy of "eating our seed corn". Market-driven forces focus on harvesting the best corn, not planting the seed. If this country is to continue to develop competitive, useful technologies for the future, a strong federal research and development role must be maintained.

IGT appreciates this Subcommittee's interest in how federal funding and cost-sharing policies specifically affect small entities such as IGT. We are proud of the quality of our work, the research contributions we have made, and the reputation we have established and maintained. We appreciate this Subcommittee's support, and I would be happy to answer any questions you may have.

Mr. STALLINGS. Thank you, Dr. Lee. Gentleman, thank you for your testimonies.

I have a couple of questions for the entire panel. The Department of Energy has informed our subcommittee that the Federal funding share of the restructured natural gas program will increase to $15 million by fiscal year 1996. Even with 50 percent cost sharing from the private sector, the total will only be $30 million. Please comment on the viability of responsible programs with such a small amount of funding.

Mr. WEBB. If I may, Mr. Chairman. We co-fund quite a bit of work with the DOE gas supply. The problem with that plan is that it is assuming even the basic research that is being done, like at the Morgantown Energy Technology Center, and some of those, will be cost shared. That's not a valid assumption.

When the technology gets to the point that it is ready to go to the field, to be demonstrated, where we can go out and get producers that are members of GRI to donate wells and allow us to do research on their wells and we are willing to put up 50 percent of the funding for those field-based activities, because if it successful, then we want to be sure we have technology transfer through having producers involved.

But a lot of the research in gas supply, especially in the speculative resources that is called for in the program plan of nearly $5 million, is stuff that you are talking about 20–10 or later. That is a legitimate Federal role to determine if the resource is there, if it can be extracted, and what some of the costs might be, before you start looking for co-funding. So to talk about a $15 million program, and that's the total program, including the speculative and basic research as well as field-based activities and then assume that you are going to get $15 million of funding from industry is an illusion.

Mr. STRANG. Mr. Chairman, I would like to comment on the gas utilization side, the end-use side, in the same respect. There are many areas in technology development—an example would be the gas-fueled fuel cell, that has been under development for a great many years. It has now reached the stage where we have the first-generation phosphoric acid fuel cell coming on the market in a pilot basis, the first 35 or 40 units next year. After 25 years or so of development of that, we are now at a point where industry is supporting that in a very significant way. We are not looking for significant dollars there.

To give you an example on the turbines, for advanced turbines, there are materials sciences being developed that can be placed inside the turbine combustors that will allow those combustors to handle the higher heat to have lower emissions. Those materials science activities are not things you can reasonably expect other people to co-fund. They are more in the basic research area.

There are other technologies that require some assistance in order to move them forward, also. In California we have some very serious restrictions or proposed restrictions on requiring lower $NO_x$ devices for things as basic as residential water heaters. The manufacturers that produce a residential water heater today at about an $80 cost and a $15 profit cannot afford to do development work that will lower the $NO_x$ levels in those residential water heaters.

Some support is required, and our company is providing that kind of support.

There are a variety of end-use technologies that require assistance early in the game. To ask for a water heater manufacturer to support that technology, they will essentially decide to put an electric probe in the bottom of that tank. For them, they are basically in the metal bending business. Yet we may need to help them to develop that low-$NO_x$ burner and the ultimate cost of that may be $35 or $50 by the time it is delivered to the marketplace.

So on the end-use side, the early areas of basic research and the early areas of technology development that have been supported in the past by DOE, such as the fuel cell, would not have reached the stage we are at today, if we had had the same onerous requirements for 50 percent co-funding.

Dr. LEE. I would like to make just two quick comments. One, we must realize R&D, to be successful, must be willing to take high risks. If we make one success out of 10, we will be doing, as a Nation, a tremendous job in doing R&D. When you have that kind of a down side risk in exploring new technology and doing new R&D, to ask for cost sharing at early stages, it is unrealistic.

The second point I would like to make is the demand placed on the application of gas resource is inequitable compared to the other energy forms. I don't recall seeing similar requirements on nuclear research, of cost sharing. If one required that, I dare say there would not be a whole lot of nuclear research going on, either. So I think the whole package ought to be done on a balanced basis, across the board, of the energy contribution made by the various sources.

Mr. STALLINGS. Do you support the reorganization of the program?

Mr. WEBB. The reorganization of the natural gas supply program?

Mr. STALLINGS. Yes.

Mr. WEBB. No, sir. We support them implementing the plan that they published last year, and that the National Energy Strategy says would be implemented.

Mr. STALLINGS. Is that feeling shared by the panel?

Mr. STRANG. Yes, it is.

Mr. WEBB. Yes.

Mr. STALLINGS. The emphasis of the current program has been on Eastern Gas Shales, Western Tight Gas Sands, or Environmental and Advanced Research Programs. For any of you that have been involved in the research program in the past years, has that research reached its realistic conclusion? If not, what remains?

Mr. WEBB. Again, let me address that. It has not reached its realistic conclusion. We have made some progress. Part of the activities we proposed for cooperative R&D ventures with DOE in the next year or two would hopefully take that one step further. One is setting up a fracturing test facility so we can really learn more about fractures and where they go in tight formations. Another one is setting up this fracture fluid laboratory, so we can determine what happens to fracture fluids in the formations and hopefully better design well completions.

And in the Devonian Shale area, we really need to do some research on how we can adopt directional drilling and horizontal drilling to get more gas per well drilled in the Devonian Shale areas. So what we think is really the basic research part is about through, and we are now ready to move into the field based activities. But we ought to look for 20 to 50 percent co-funding from industry, and we are certainly willing to do that in conjunction with DOE.

But it is premature to say that all they ought to do is the $8 million of 50-50 cost shared activities.

Dr. Lee. The tendency seems to be that once you have a producing or a number of producing wells in the Eastern Shale or Tight Formations, the job is done, therefore it should be turned over to industry. That is totally false. In other words, we have been producing oil for a long, long while. But new technologies in deep drilling, directional, offshore, deep water, continues to demand R&D dollars at high risk.

The same thing occurred with nuclear power plants for many, many years. But the development for safer, better, more efficient plants are always required. So the concept that Tight Formation is commercial and therefore does not require R&D is false. All sorts of good R&D is required and will be beneficial in the long term.

Mr. Strang. Mr. Chairman, I also feel the same way about the end-use research. As an example, there is one technology available, the fuel cell I mentioned earlier, but there are two or three additional technologies that need further development. To suggest that those are completed at this point in time is not at all the case.

Similarly, with the heat engines and gas turbines areas, there are many additional projects needed to further high-efficiency, low emitting turbine development work, and the fact that a turbine may be on the market in a particular size that is less polluting than what was available a few years ago does not at all preclude the need to develop turbine engines of different sizes, of higher efficiencies. There is much work to be done in that area.

Mr. Webb. If I could just make one more comment. I do think in the case of methane from coal seams that the Government role really is finished. I think industry ought to take what we have learned in the stuff down in Alabama in the San Juan Basin and we ought to start applying that in other regions, and that ought to be the responsibility of industry. Because we are far enough along with the technology that commercial development is beginning to progress. So with that one resource base, I think yes, the DOE role is finished. But certainly not in the others.

Mr. Stallings. Thank you. Mr. Smith.

Mr. Smith. Thank you, Mr. Chairman. I would like to ask some questions that go beyond your testimony, simply to take advantage of your expert opinions, and come back to your testimony in a minute.

Mr. Strang, let me ask you your opinion of the President's proposal to deregulate natural gas pipelines and ask you what impact you think that will have on the industry, and what impact it will have on the supply and demand

Mr. Strang. As I understand the proposal, it is basically to streamline the procedures used to certify pipelines such that pipelines could be built with fewer restrictions in terms of actually getting certified. There are certainly areas in the country where additional pipeline capacity could be very helpful. We have, as Mr. Webb has said——

Mr. **Smith**. Particularly in the northeast part of the country?

Mr. **Strang**. I think so, in the northeast part. I have less personal experience in the northeast than I have in the western part of the country. But I think that anything that can give additional transportation capability into those areas to serve can be of some benefit.

We caution against a view that total deregulation of a process is going to simplify the process. In the past, some of the term deregulation has really been used to identify a different method of regulation, a shifting of one kind of regulation for another. So anything that would provide additional access would be beneficial. To put a label on it one way or the other, one would have to look at the specific rules and make sure those rules really facilitated the end result that you see.

Mr. **Smith**. Thank you.

Mr. Webb, are there any research results that have been obtained from the unconventional gas recovery programs that you feel are going to be able to have immediate commercial use or are expected to have immediate commercial use?

Mr. **Webb**. Yes, sir, in two areas. One is, as I mentioned, coal bed methane. We started researching coal bed methane in 1980, starting with what was called at the time "moonbeam gas" and there was a lot of skepticism about whether it made any sense. Today they are producing something on the order of 300 billion cubic feet per year and the number of production is estimated to double.

Another one is in this cooperative venture we have with the University of Texas Bureau of Economic Geology. We are developing in there, if you would, a process whereby we think we can identify how to drill within existing fields and get additional gas recovery, from zones that have been bypassed. Coming out of that are two technology developments we think will be very beneficial.

One of the objectives is to develop an instrument so that you log through casing, so you can go back into an existing, completed well that may have been plugged, log through that casing, discover zones that were passed as we drilled through there, which means that you don't have to incur the 60 percent cost on the front end through the drilling and the completion of the well.

The other is some seismic logging techniques with new computer technology we think will allow us to go between existing wells and identify bypassed pockets of gas that would tell you where to do your infield drilling. Those, within the next three years, we think will be commercially feasible and you will see it being used more and more in existing fields in secondary gas recovery work.

Mr. **Smith**. Do you have any estimate as to the potential recovery of that technique? That sounds very promising.

Mr. **Webb**. The only estimate that has been made was made by the Department of Energy about two years ago. They estimated in the total lower 48 States that there were about 125 trillion cubic feet of what they called gas that could be recovered through secondary gas recovery in known fields. The economics of that have not been determined, so to say that there is 125 trillion cubic feet at $3, we don't know that. But the estimate is 125 trillion cubic feet.

If that's correct, that's a major resource that is already in areas where you have existing collection and distribution systems.

Mr. SMITH. Thank you for the response. That is encouraging, and I appreciate the specifics.

Dr. Lee, you mentioned in your testimony a while ago, or used the phrase that Congress should not forget energy R&D. I couldn't agree with you more. You also happened to mention some of the benefits of natural gas. We all know it is abundant, available, clean burning and so on.

Given the various budgetary constraints we all operate under, what would be your priorities as far as research and development projects go? I think that's a question I would like to ask you and the other panelists as well, since they may have different views. But what would be your priorities?

Dr. LEE. Well, that certainly is a fair question. When you have many choices, we all like to prioritize. But I will make two comments.

One, we must attack this long term energy utilization and supply situation from a multi-entry type approach. One does not pick one technology and say that's the one we will ride with. We have to go at it from a number of directions.

Two, I would like to comment on the two aspects of energy, the supply of energy and the utilization of energy. From my perspective, as an R&D person, as an R&D person working for an R&D organization, our task is to work on technology that is going to last for a while, that will take a number of years of support. We are very interested in this committee's direction, asking for three-year planning. This is a direction we ought to be moving. Year by year type of planning is very difficult and many times disruptive to good work.

My views tend to be on the longer term, perhaps, than other people who have technology ready to commercialize. I think the long-term part is critical.

Having said all that, on the supply side, I would support the stimulation methods of various sorts, and formation that Mr. Webb spoke about on the gas side. But I would also suggest that we look at alternatives for the longer-term in the Nation's overall energy mix, the clean use of coal, the clean use of shale are all resources the Nation will need in the total energy package. I would certainly include them as important elements.

On the utilization side, yes, I think at the top of the list would be fuel cells, as a technology that has many, many benefits, in addition to clean burning, high efficiency, modular, noiseless and all those good characteristics. The second part I believe is important would be the whole package of technologies, individually small but collectively very significant, of low $NO_x$ emitting, low pollutant emitting, combustion technology.

As I said before, these are small items, the manufacturers are small, they do not have the resources, nor do they have the interest in selling the piece of hardware. The benefit to society is much bigger than the benefit to the person who welded up that piece of burner.

So the whole package of combustion equipment, to me, would be significant.

Mr. **Smith**. Thank you. I think that's just the kind of priority list we need.

Mr. Webb, Mr. Strang, do you have anything to add to that?

Mr. **Strang**. I would just like to add, with Dr. Lee, that I think those priorities fit exceptionally well for us, with the fuel cell. I think also in the areas of high efficiency, low polluting turbines, there is an illusion that we have all of the air emissions problems licked in the country. I think we need to continue to put R&D efforts into the natural gas side. Because we have such a positive image as a clean burning fuel there are those who often feel that nothing more is needed.

As Dr. Lee said, many times small components can add significant improvements. Examples would be some dollars into the emission controls area, where through a controlling device that in effect senses what is going on in an engine or a turbine, one can get better, cleaner kind of air emissions from that device. So some of the smaller dollars spent in that area can often be applied in many other applications.

I would also add that in the natural gas vehicle area, there certainly are good systems in place. But there are certainly additional efforts needed to support a variety of components and systems to support natural gas in the fueling situation for motor fuels.

Mr. **Smith**. Thank you, Mr. Strang.

Mr. Webb, do you have anything to add?

Mr. **Webb**. Just one thing. I would certainly agree on the end use side, fuel cells and the whole area of emissions control and efficiency. In the natural gas vehicles, really what we need to do there is have a significant joint Federal-industry program in storage technology. If we could figure out a medium so that we could store compressed natural gas at higher densities than we can today at lower pressures, and we could bring down the cost of conversion significantly, we might even get to the point where we also ought to look at home compression.

If for $300 I could put into your garage a compressor, and when you drove your car home each night, that you commute in, and you plugged it in, and each morning you went out with a full tank of gas, and it comes in your gas bill, just like when you use your furnace or something, we could make significant breakthroughs. For those two areas in natural gas research we ought to have a joint Federal-industry program.

On the supply side, I think the unconventional gas program ought to be implemented.

Mr. **Smith**. Thank you all.

Thank you, Madam Chair.

Mrs. **Lloyd**. I think Mr. Stallings and Mr. Smith have pretty well covered the issues before the committee. I thank them for their cooperation.

I want you to know that this committee certainly is very supportive of gas research and development. I think we see ever so clear not only the potential of natural gas vehicles but also the great potential in fuel cells. Where I really want to come down is I hope there can be an agreement reached with those of you that are proponents of the need and potential of gas, to work with the Department of Energy to see where we can really delineate the responsibilities in cost sharing. Perhaps we don't need to go to 50 percent in some areas, and in some areas perhaps you can do more. Perhaps on the front end there should be greater Federal involvement.

But I think it is very important that this issue be addressed in a coherent manner this year. I think it is also very important that the Administration live up to its responsibilities. Indeed, Mr. Smith, I think this is very important, as we saw when we had the hearings on MHD. We are promoting this year—probably as never before—cost sharing between industry and the Federal Government. But when the Federal Government reneges on commitments they have made in previous years, then industry that has to answer to their stockholders is going to look with a dubious eye towards this sort of commitment.

I do think it is important that if we are going to ask for cost sharing, which I believe in, everyone on this panel is going to agree with this concept, but at the same time it is important we be reliable partners, that we take care of our end of the seesaw.

We thank you very much.

Mr. SMITH. Madam Chair, I appreciate the opportunity you have given me to introduce this final panel, which will discuss oil research and development programs. If you all will come forward, I will introduce you at this point. Dr. Thomas Hyde comes to us from the University of Texas of the Permian Basin, which is in Odessa, Texas. Mr. James Deterding is Vice-President and Director of the National Institute for Petroleum and Energy Research, and Dr. Frank Derbyshire is the Director of the Center for Applied Energy Research at the University of Kentucky.

We welcome each of you today. Dr. Hyde, if we may start with you?

## STATEMENT OF DR. THOMAS A. HYDE, P.E., PROFESSOR AND CHAIRMAN OF ENGINEERING, THE UNIVERSITY OF TEXAS OF THE PERMIAN BASIN

Dr. HYDE. Madam Chairman and members of the subcommittee, I am Thomas A. Hyde, Chairman and Professor of Engineering, at the University of Texas of the Permian Basin. Thank you for this opportunity to discuss the 1992 Department of Energy fossil fuel research development and demonstration budget.

Your efforts to address carefully the funding priorities for fossil fuel research are to be commended. My testimony requests the Congress to consider substantial increases in energy research funding, particularly in funding for demonstration programs. Both large and small companies in the energy industry have an immediate and pervasive problem: what are the effective economic ways to manage waste streams of water, air and solids, while improving energy production?

Solving this problem will require the mobilization of industry, university and government resources, because waste stream management has an impact on all RD&D programs. However, we do not have enough commercial grade technology demonstration data to guide our efforts to resolve the toxicological problems of commercial level waste streams.

Honorable members of the subcommittee, as you know, there are three areas of technological advancement: basic research, pilot plant development, and commercial grade demonstration. All three are expensive, all three are risky. All three demand our attention.

Today, however, I want to focus upon demonstration projects. It is imperative that we move critical technologies out of the laboratory into the field. We have a number of emerging technologies that can be applied to oil, gas and petrochemical waste streams, including thermal treatment processes for drilling fluids, waste minimization techniques, bioremediation, wet air oxidation and supercritical water oxidation.

It is not possible to address all these emerging technologies here, therefore, I have chosen three examples from dozens to show that additional RD&D fossil energy funding is essential to support commercial grade demonstration projects.

My first example is supercritical water oxidation. This emerging technology has potential application to a host of waste streams, including groundwater contaminated with organics, hydrocarbon based fluids and solids, soils contaminated by oil spills, mixed waste containing both organics and radioisotopes, potentially explosive materials and augmentations to waste streams currently going to incineration facilities.

This technology has solved many problems at the laboratory bench scale stage. The Department of Energy, national laboratories and a number of university laboratories have a substantial investment in this technology. A commercial grade demonstration of this technology does not exist.

A major oil company would like to develop a commercial grade demonstration project to address the waste stream problems in oil and gas field and petrochemical plants. However, neither this company nor any other can shoulder the upfront investment alone. As a DOE-supported program, this emerging technology needs significant additional funding.

My second example is bioremediation and bioreactor technology. This technology has the potential to augment waste stream management programs by using natural processes, to reduce hydrocarbon and organic contaminants. There have been several commercial attempts to validate bioremediation technology. Some success in anaerobic and aerobic small scale bioreactors has been achieved for specific waste streams.

Yet there are no significant commercial grade demonstration programs that encompass the broad spectrum of bioreducing technology. Moving these technologies from the laboratory into the field is accompanied by many uncertainties. Significant funding for commercial demonstrations must be forthcoming so that this emerging technology can be evaluated further, especially in fossil fuel environmental restoration operations.

My third example is waste-to-fuel pyrolysis. One 12-year research project has been funded by the DOE and others and today represents the world benchmark technology in pyrolysis waste-to-fuel research. This technology can now be upgraded from pilot plant to demonstration plant. The process developers are seeking joint partners for a commercial scale demonstration plant using wood pulp and municipal solid waste. This technology may also be applicable to the environmentally safe destruction of petroleum waste streams such as tank bottoms.

A considerable investment in this process has been made; indeed, it is one of the few emerging technologies with a complete economic analysis for a commercial grade demonstration plant. This technology deserves further DOE support at this final stage of its development.

Let me emphasize that these are but three examples of dozens of emerging technologies that require Federal assistance to be moved out of the laboratory into the field. It is often assumed that technical risks and therefore financial risks are highest at the front end of research programs. Exactly the opposite case can exist, especially for commercial grade demonstration projects requiring multiple technologies to solve simultaneously the problems of enhanced oil production and enhanced environmental protection.

I shall now shift my remarks to the Permian Basin, the largest crude oil and natural gas producing region in the contiguous United States. The Permian Basin encompasses 54 counties in West Texas and four counties in New Mexico, with a surface area of 100,000 square miles of high desert. There are over 98,000 wells in production here, representing approximately one-sixth of the wells in the United States. The Basin produces over 1.1 million barrels of oil and 1.1 billion cubic feet of gas per day, representing approximately 17 percent of the Nation's domestic crude oil and 11 percent of the Nation's natural gas. The Permian Basin also contains 22 percent of the known crude oil reserves of the United States.

Yet this important oil and gas producing region has no Federal energy field office, no Environmental Protection Agency field office, no Federally-assisted technology demonstration projects, no energy RD&D programs of any consequence, and no direct government support for its independent producers, major oil companies, petrochemical companies and oil and gas service companies—all of which are trying to cope with energy waste management problems.

The petroleum industry's exploration and production problems in the Permian Basin are representative of the problems facing the industry in other regions. The Congress can help by providing increased funding for commercial grade technology demonstration programs that will enhance the production of this region and, through technology transfer, of other regions.

Honorable members of the subcommittee, I recommend that the fossil energy budget be increased for at least four reasons. One, the Department of Energy should be capable of supporting all three phases of technological development. A fundamental problem with the Department's RD&D funding level is the lack of support for the critical third phase—commercial grade demonstrations. For example, the cooperative R&D portion of the 1992 budget is $5 million. This entire amount would support less than one-third of the cost of developing the first commercial grade supercritical water oxidation demonstration plant.

Two, small companies and independent producers are responsible for a significant portion of the United States' oil and gas production. However, they cannot readily participate in RD&D programs. They do not have the financial resources and the broad-based scientific and engineering expertise required. Thus, RD&D funding to support joint venture programs among the DOE-supported national laboratories, major corporations, and universities is essential to the continuing ability of thousands of smaller companies and independent operators to meet their responsibilities for ecologically sound production.

Three, the Department of Energy should be enabled to continue to support technologies that turn energy waste into useful products.

Four, the Environmental Restoration portion of the 1992 fossil energy RD&D budget is $8 million. This is far too low. This portion of the budget should be increased significantly to address the environmental restoration problems facing an industry that has set as its primary goal sustained production with environmental protection.

Madam Chairman and members of the subcommittee, thank you for this opportunity to discuss the 1992 fossil fuel research budget.

[The prepared statement of Dr. Hyde follows:]

# Testimony by

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Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy
The Honorable Marilyn Lloyd, Chairman

The Rayburn House Office Building
Room 2318
Washington, D. C.
March 14, 1991

**Testimony by: Thomas A. Hyde, Ph.D., P. E.**
**The House of Representatives Committee on Science, Space, and Technology**
**Subcommittee on Energy, March 14, 1991**

## ABSTRACT

This testimony addresses the 1992 Department of Energy fossil energy RD & D budget. Emphasis is placed upon the central problem facing the United States oil and gas industries, to wit: What are the effective, economic ways to manage waste streams of water, air, and solids while maintaining and improving energy production? Special attention is given to commercial-grade demonstration projects for emerging technologies, including supercritical water oxidation, bioremediation and bioreactor processes, and waste-to-fuel conversion. This testimony recommends substantially increasing the Department of Energy fossil energy RD & D budget.

Industry associations represented by this testimony are: The Permian Basin Petroleum Association; The North Texas Oil and Gas Association; The West Central Texas Oil and Gas Association; The East Texas Producers and Royalty Owners Association; and, The Panhandle Producers and Royalty Owners Association.

**Testimony by: Thomas A. Hyde, Ph.D., P.E., March 14, 1991**
**HR Committee on Science, Space, and Technology, Subcommittee on Energy**

Madam Chairman and Members of the Subcommittee on Energy, thank you for this opportunity to discuss the 1992 Department of Energy fossil fuel research, development, and demonstration (RD & D) budget. I am Thomas A. Hyde, Professor and Chairman of Engineering, The University of Texas of the Permian Basin. I am a graduate of the United States Naval Academy and of the University of Pennsylvania, a National Science Foundation Science Faculty Fellow, and a recipient of the Permian Basin Engineer of the Year award.

I am honored today to provide testimony to this Subcommittee on behalf of a number of industry associations, colleagues in the scientific and engineering communities, and associates in the oil, gas, and petrochemical industries. I hope to provide a down-to-the-basics focus upon key problems in these industries.

Honorable Members of the Subcommittee, your efforts to address carefully the funding priorities for fossil fuel RD & D programs are to be commended. My testimony requests The Congress to consider substantial increases in energy RD & D funding, particularly an increase in funds for research-demonstration programs.

Both large and small companies in the energy industry have an immediate and pervasive problem: What are the effective, economic ways to manage waste streams of water, air, and solids while maintaining and improving energy production? [DOE, 1990a; EPA, 1987] Solving this problem will require the mobilization of industry, university, and government resources. Waste-stream management has an impact on all RD & D programs. However, we do not have enough commercial-grade technology-demonstration data to guide our efforts to resolve the toxicological problems of commercial-level waste streams.

## Commercial-grade Demonstration Programs

Honorable Members of the Subcommittee, as you know, there are three areas of technological advancement: basic research, pilot plant development, and commercial-grade demonstration. All three are expensive. All three are risky. All three demand our attention. Today, however, I focus upon demonstration projects because it is imperative that we move critical technologies out of the laboratory into the field.

We have a number of emerging technologies that can be applied to oil, gas, and petrochemical waste-stream problems. These technologies include: incineration and other thermal treatment processes for drilling fluids; waste minimization techniques for conservation, recycling, and reuse; bioremediation; wet air oxidation; and supercritical water oxidation. It is not possible to address all of the emerging technologies here. Therefore, I have chosen three examples from dozens to show that additional RD & D fossil energy funding is essential to the support of commercial-grade demonstration projects.

### Supercritical water oxidation technology

My first example is supercritical water oxidation technology. This emerging technology has potential application to a host of waste streams, including: groundwater contaminated with organics; hydrocarbon-based fluids and solvents; soils contaminated by oil spills; mixed wastes containing both organics and radioisotopes; potentially explosive materials; and augmentations to waste streams currently going to incineration facilities for destruction. [LANL, 1989; UTA, 1990] This technology has solved many problems at the laboratory bench-scale stage. [SNL, 1990a] The Department of Energy, National laboratories, and a number of university laboratories have a substantial investment in this technology. A commercial-grade demonstration of this technology does not exist. A major oil company would like to develop a commercial-grade demonstration project to address the waste stream problems in oil and gas fields and in petrochemical plants. However, neither this company, nor any other, can shoulder the up-front investment alone. As a DOE-supported program, this emerging technology needs significant additional funding.

**Bioremediation and bioreactor technology**

My second example is bioremediation and bioreactor technology. This technology has the potential to augment waste-stream management programs by using natural processes to reduce hydrocarbon and organic contaminants. [NCTR, 1989] There have been several commercial attempts to validate bioremediation technology. Some success in anaerobic and aerobic small-scale bioreactors has been achieved for specific waste streams. Yet, there are no significant commercial-grade demonstration programs that encompass the broad spectrum of bio-reducing technology. Moving these technologies from the laboratory into the field is accompanied by many uncertainties. [NCTR, 1984; DOE, 1990b] Significant funding for commercial demonstrations must be forthcoming so that this emerging technology can be evaluated further, especially in fossil-fuel environmental restoration operations.

**Waste-to-fuel pyrolysis technology**

My third example is waste-to-fuel pyrolysis technology. One twelve-year research project has been funded by the DOE and others, and today represents the world "bench-mark" technology in pyrolysis waste-to-fuel research. [GTRI, 1989; 1990] A 60-70 percent by weight conversion of waste to pyrolysis fuels has been achieved; the technology can now be upgraded from pilot plant to demonstration plant. The process developers are seeking joint partners for a commercial-scale demonstration plant using wood-pulp and municipal-solid wastes. This technology may also be applicable to the environmentally safe destruction of petroleum waste streams such as tank-bottoms. A considerable investment in this process has been made; indeed, it is one of the few emerging technologies with a complete economic analysis for a commercial-grade demonstration plant. This technology deserves further DOE support at this final stage of its development.

Let me emphasize that these are but three examples of dozens of emerging technologies that require Federal assistance to be moved out of the laboratory into the field. [DOE, 1990b]

It is often assumed that technical risks and therefore financial risks are highest at the "front-end" of research programs. [DOE, 1991:97] Exactly the opposite case can exist, especially for commercial-grade demonstration projects requiring multiple technologies to solve, simultaneously, the problems of enhanced oil production and enhanced environmental protection.

**The Permian Basin**

I shall now shift my remarks to the Permian Basin, the largest crude oil and natural gas producing region in the contiguous States. The Permian Basin encompasses 54 counties in West Texas and 4 counties in New Mexico with a surface area of 100,000 square miles of high desert. There are over 98,000 wells in production here, representing approximately one-sixth of the wells in the United States. The Basin produces over 1.1 million barrels of oil and 1.1 billion cubic feet of gas per day, representing approximately 17 percent of the Nation's domestic crude oil and 11 percent of the Nation's natural gas. The Permian Basin also contains 22 percent of the known crude oil reserves of the United States.

Yet, this important oil- and gas-producing region has no Federal energy field office; no Environmental Protection Agency field office; no Federally assisted technology demonstration projects; no energy R & D programs of any consequence; and no direct governmental support for its independent producers, major oil companies, petrochemical companies, and oil and gas service companies, all of which are all trying to cope with energy waste management problems. The petroleum industry's exploration and production problems in the Permian Basin are representative of the problems facing the industry in other regions. The Congress can help by providing increased funding for commercial-grade technology demonstration programs that will enhance the production of this region and, through technology transfer, of other regions.

**Recommendations**

The final part of my testimony makes recommendations. Honorable Members of the Subcommittee, higher funding levels are required to support near- and mid-term hydrocarbon geoscience research. [DOE, 1990c; 1990d; 1990e] The proposed decrease in the 1992 fossil energy budget from $463 million in 1991 to $227 million in 1992 could severely damage the ability of the United States to maintain world-class energy research leadership. Today, companies developing our energy resources can no longer separate exploration and production costs from environmental protection costs. The DOE must have the opportunity to support the effort of energy industries to meet the challenges they face.

I recommend that the 1992 fossil energy RD & D budget be increased substantially for at least four reasons.

**One:** The Department of Energy should be capable of supporting all three phases of technological development: basic research, pilot plant development, and commercial-grade demonstration projects. A fundamental problem with the Department's RD & D funding level is the lack of money to support the critical third phase: commercial-grade demonstrations. For example, the *Cooperative R & D* portion of the 1992 budget is $5 million. This entire amount would support less than one third of the cost of developing the first commercial-grade supercritical water oxidation demonstration plant.

**Two:** Small companies and independent producers are responsible for a significant portion of the United States oil and gas production. However, they cannot readily participate in RD & D programs; they do not have the financial resources and the broad-based scientific and engineering expertise required. Thus, RD & D funding to support joint-venture programs among the DOE-supported National laboratories, major corporations, and universities is essential to the continuing ability of thousands of smaller companies and independent producers to meet their responsibilities for ecologically sound production.

**Three:** The Department of Energy should be enabled to continue all three phases of RD & D support for technologies that turn energy waste into useful products. These technologies can play a crucial role in the national economy.

**Four:** The *Environmental Restoration* portion of the 1992 fossil energy RD & D budget is eight million, eighty-five thousand dollars. This is far too low. This portion of the budget should be increased significantly to address the environmental restoration problems facing an industry that has set as its primary goal: sustained production with environmental protection.

Madam Chairman and Members of the Subcommittee, thank you for this opportunity to discuss the 1992 fossil fuel RD & D budget. If you have questions, I shall be happy to answer them.

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DOE: The United States Department of Energy, Washington, D. C.; EPA: The United States Environmental Protection Agency, Washington, D. C.; GTRI: Georgia Tech Research Institute, Atlanta, Georgia; NCTR: National Center for Toxicological Research, Jefferson, Arkansas; LANL: Los Alamos National Laboratory, Los Alamos, New Mexico; SNL: Sandia National Laboratories, Livermore, California; UTA: The University of Texas, Austin, Texas.

**Testimony by: Thomas A. Hyde, Ph.D., P.E., March 14,1991**
**HR Committee on Science, Space, and Technology, Subcommittee on Energy**

## Supplement

[1] In September, 1990, The University of Texas of the Permian Basin and The University of Texas at Austin inaugurated a Master of Science in Petroleum Engineering program taught at U. T. Permian Basin by both faculties, with the degree granted by U. T. Austin. This unique program offers the first Petroleum Engineering degree in the Permian Basin in its seventy-year history of oil and gas production. The U. T. Austin Petroleum Engineering Department is "number one" in the United States. [USNWR, 1990] The program increased graduate enrollment in Petroleum Engineering at U. T. Austin by 25 percent in four months. The Master of Science in Petroleum Engineering program has the financial support of the petroleum industry and Southwest Airlines. The students have an average of seven years of experience in the petroleum industry.

[2] In April, 1991, The University of Texas of the Permian Basin Engineering Department will sponsor a seminar at the new Center for Energy and Economic Diversification in Midland to bring together National, university, and industrial laboratories, and oil, gas, and petrochemical companies to discuss solutions to waste-stream problems in the context of moving emerging technologies "out of the lab into the field." Several laboratories and companies have been invited to the seminar: Los Alamos National Laboratory; Sandia National Laboratories; The National Center for Toxicological Research; Oak Ridge National Laboratory; The National Institute of Standards and Technology; U.S. Geological Survey; U. S. Department of Energy, Bartlesville; The National Institute for Petroleum and Energy Research; The Energy and Environmental Research Center, The University of North Dakota; The University of Texas at Austin; The Georgia Tech Research Institute; The Gas Research Institute; The American Petroleum Institute; ICF Resources, Inc; Arco; Amoco; BP America; Chevron; Conoco; Exxon; Fina; Marathon; Mobil; Oryx; Oxy; Phillips; Rexene; Shell; Texaco; and Unocal. The response to this unique seminar has been positive and enthusiastic.

[USNWR, 1990] *U. S. News and World Report*, March 19, 1990.

## Supplement

### Supercritical water oxidation

"Supercritical water oxidation [seems to be] a homogeneous-phase process that occurs in water at temperatures and pressures above [ ] the critical point [of water]. Under these conditions, water is a fluid with unique properties that can be used to advantage in the destruction of hazardous wastes. With a density between that of water vapor and liquid at standard conditions, the fluid exhibits elevated, gas-like diffusion rates along with high, liquid-like collision rates. In addition, solubility behavior [seems to be] reversed so that chlorinated hydrocarbons become soluble in the water, allowing single-phase reaction of aqueous waste with a dissolved oxidizer. [In some cases] the reversed solubility also causes salts to precipitate out of solution, meaning they can be treated using conventional methods for solid-waste residuals. As a beneficial consequence of these unique properties, efficient oxidation reactions occur at [moderate] temperature (400 - 650°C) with reduced NO$_x$ production." [SNL, 1990b]

### Waste-to-fuel pyrolysis

"Fast or flash pyrolysis is a thermochemical technique for conversion of biomass materials to valuable gaseous and condensable hydrocarbon products which involves rapid heat-up of particulate biomass feeds in a pyrolyzing gas stream at [fast] rates, maintaining the reactants at a desired reaction temperature for relatively short periods of time (seconds) followed by rapid cooling/condensation of the reaction products at [fast] rates. The total yield of volatile products obtainable in fast pyrolysis processes have been shown to be significantly higher, theoretically and experimentally, than by conventional and direct (including catalytic) pyrolysis conversion processes. The latter usually involve slow heat-up rates and longer high-temperature reaction residence times (minutes, hours). Secondary and tertiary reaction mechanisms, involving the primary volatile products on residual solid surfaces and with each other, with resultant tar and char formation are minimized due to short residence times and rapid cooling. Consequently, the objective of fast pyrolysis technology is to maximize the oil yields from biomass feedstocks.

There are three principal processes under development with the support of Federal funding in the United States:

(1) The Georgia Tech Research Institute Entrained Flow Pyrolysis Process.

(2) The Solar Energy Research Institute Ablative Pyrolysis Process.

(3) The Brookhaven National Laboratory Flash Pyrolysis Process." [GTRI, 1989]

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| [SNL, 1990b] | S. C. Johnston and C. E. Tyner, *Thermochemical Waste Processing Technology at Sandia National Laboratories*, presented at Envirotech Vienna 1990 conference, October 25, 1990. |
| [GTRI, 1989] | D. J. O'Neil and R. J. Kovac, *Advanced Biomass Pyrolysis Technology in the U. S.*, in Pyrolysis as a Basic Technology for Large Agro-Energy Projects, M. E. Grassi, and W. Palz, eds., Commission of the European Communities, Luxembourg, 1989. |

Mrs. Lloyd. Thank you very much, Dr. Hyde.

Mr. Deterding?

## STATEMENT OF JAMES M. DETERDING, VICE PRESIDENT AND DIRECTOR, IIT RESEARCH INSTITUTE, NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH, ACCOMPANIED BY DR. TOM BURCHFIELD, DIRECTOR OF ENERGY PRODUCTION, NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH

Mr. Deterding. Thank you, Madam Chairman and members of the subcommittee.

I very much appreciate this opportunity to provide some brief comments relative to the fiscal year 1992 DOE fossil energy budget request. I do this as a representative of the National Institute for Petroleum and Energy Research, or NIPER, in Bartlesville, Oklahoma, and the IIT Research Institute, which has operated NIPER since its conversion to a private, not-for-profit status in 1983. I also have with me this morning Dr. Tom Burchfield, the Director of Energy Production Research at NIPER, to assist me in answering questions.

Mrs. Lloyd. We welcome you as well, Dr. Burchfield.

Mr. Deterding. I will attempt to briefly summarize the contents of the written statement that was submitted to you earlier. My comments will be limited to technical aspects of the oil and gas R&D program. We recognize that our views toward petroleum R&D needs may be influenced by the somewhat unique nature of our organization and client base.

At NIPER, we are exposed to industry research programs and perceived needs as well as to the petroleum-related R&D program of the Federal Government. We do believe it is very important to integrate the programmatic interests of the DOE with research interests and needs of the private sector to the maximum extent possible. Ideally, that integration should include both the major oil companies' interests and those of the small independent producers which play such a vital role in our Nation's total gas and oil production.

I believe that responsible technology driven research programs of the future should include at least three major components. One, efforts to produce oil that has been left behind after conventional primary and secondary recovery methods. Two, research efforts directed at maximizing the availability of alternative fuels, including those measures necessary to efficiently produce finished products from heavier crudes. Three, research and development programs specifically aimed at technically based data and solutions for environmental issues associated with petroleum production, refining, transportation and use.

With recent events in the Persian Gulf still fresh in the minds of our citizens, we hardly need to be reminded of the importance of oil to both our daily lives and the Nation's security. As a general indication of that importance to the smooth operation of our overall economy, we should remember that oil supplies an estimated 43 percent of the Nation's primary energy, and an estimated 97 percent of the energy used for transportation of people and goods.

There is also a general awareness of our growing dependence on oil imports, as a result of declining domestic oil production without a corresponding decrease in consumption. The National Energy Strategy recognizes this situation of U.S. vulnerability to supply disruptions. It specifically delineates the importance of research and development funds to promote the use of advanced oil recovery technologies to maximize economic production of U.S. oil resources.

The initial approach to this end is detailed in the U.S. Department of Energy's Oil Research Program Implementation Plan, which is known as ORPIP, published in April of 1990. We applaud the approach outlined in that plan related to recovery of portions of the more than 300 billion barrels of oil remaining in place after conventional production methods, and reflection of that in the fossil energy budget request.

But we also would like to suggest several specific areas for broadening the plans applicability and usefulness to the research needs of the private sector, as viewed from our perspective at NIPER. We are also recommending that the fossil energy R&D budget be increased accordingly to accommodate such an expansion.

The present ORPIP, as written, is directed primarily at improved light oil recovery. Similar detailed planning and initiation of R&D activities for heavy oil deposits should commence as soon as possible. Technology transfer and commercialization activities are critical to the success of the near-term and mid-term program objectives outlined in that plan. With respect to planned field tests that form a part of those programs, we believe that a very flexible posture by DOE with respect to cost sharing requirements will result in maximum benefits and participation by both small, independent producers and large oil companies.

In addition, we would urge that funds be authorized for a program dedicated to technology transfer, specifically for small, independent oil and gas producers. We believe it is especially important to assure that ongoing long term and fundamental research efforts needed to advance technology, including university and science education programs, will not be compromised by the urgency of near-term and mid-term research efforts.

While actively engaging in the commercialization of technology now available, we must also guarantee that new technology will continue to be developed and available for transfer in future years. We can't afford to run out of new technology.

We recommend that the budget for enhanced oil recovery be increased to $48 million to provide adequate funding for long-term research efforts while also pursuing near-term and mid-term program objectives outlined in the ORPIP.

Research programs applied to the development and utilization of alternative fuels should be assigned a high priority. Availability of alternative fuels is one more component of a necessary plan to assure secure transportation energy sources for the future. Along with these efforts, we must also continue the R&D related to processing and refining problems associated with heavy oils and less desirable feed stocks.

In all of these efforts, thermodynamics research capabilities are required to provide data necessary for efficient production of fuel products. We recommend that the thermodynamics research activities at NIPER, which are now producing such data, and one of the few places where such data is produced, be directly funded at a level sufficient to ensure continued research activities and to provide for its continuing role as a critical technical resource of the Nation.

The National Energy Strategy includes a commitment to a safer and healthier environment. With respect to oil production, processing and utilization, that includes concerns for protection of environmentally sensitive areas. It also includes proper handling and disposal of exploration and production wastes, monitoring and control of emissions from all sectors of the industry, and procedures for efficiently dealing with oil transportation accidents.

We believe DOE should play a leading role in concert with other Government agencies and industry in research programs that address the impact of petroleum production, refining and distribution on our environment. We recommend that funds be specifically authorized within the DOE fossil energy budget for research and development aimed at finding solutions to identified environmental problems, and assuring that such solutions are based on sound technical facts.

We also recommend that a portion of those R&D funds be designated to provide information and assistance to independent operators in complying with the mitigation requirements of environmental regulations associated with oil and gas exploration and production.

That is a short summary of the contents of my written statement. Again, I thank you for this opportunity and I will be happy to answer any questions.

[The prepared statement of Mr. Deterding follows:]

# STATEMENT OF

**Mr. James M. Deterding**
**Vice-President and Director**

IIT RESEARCH INSTITUTE
NATIONAL INSTITUTE FOR PETROLEUM AND ENERGY RESEARCH

before the

SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 14, 1991

Madame Chairman and Members of the Subcommittee:

I am Jim Deterding, Director of the National Institute for Petroleum and Energy Research (NIPER) in Bartlesville, Oklahoma, and Vice President of the IIT Research Institute which has operated NIPER since its conversion to private, not-for-profit status in 1983. I am very grateful to you for this opportunity to present some views relative to the Fiscal Year 1992 budget request for the U.S. Department of Energy's Fossil Energy Program.

My remarks will address a very narrow portion of that budget request, specifically, that related to petroleum and associated environmental concerns.

NIPER is generally recognized as the preeminent independent petroleum research facility in the United States and is located in the heart of the energy producing states of the mid-continent region. Its capabilities are built on a unique heritage of internationally recognized petroleum technology expertise developed under the leadership of DOE at the Oklahoma laboratories, and the rich diversity of human resources and record of technological accomplishments for more than half a century at the IIT Research Institute. The IIT Research Institute is one of our nation's largest not-for-profit R&D organizations with more than 1700 employees, facilities in 17 locations, and annual R&D business volume in excess of $125 million.

Our views toward R&D requirements for energy production, energy consumption, and associated environmental issues are, in part, influenced by the breadth and diversity of our client base. Specifically, those influences include direct observation, interaction, and performance of petroleum-related R&D for the U.S. Department of Energy (DOE); energy and environmental R&D for other federal and state agencies; and R&D, technology development, and technology transfer for the private sector.

It is important that programmatic directions of federally-funded R&D in energy and in related environmental issues be consistent, as closely as is possible, with short-term and long-term interests of the private sector. In this connection, it seems clear that a responsible technology-driven petroleum research program must include at least the following three requirements: 1) the need to produce oil that has been left behind after application of conventional primary and secondary recovery methods; 2) the need to be able to efficiently produce fuels from heavier crudes, and to objectively assess the relative economics, efficiencies, and environmental impacts of alternative fuels such as reformulated gasolines, ethanol, methanol, and natural gas; 3) the need to address environmental issues directly associated with petroleum production, refining, and use, such as disposal of oil field brines, drilling wastes, and catalysts; groundwater contamination; and combustion emissions.

The U.S. economy's heavy dependence on petroleum is well documented and is expected to continue for many years to come. At the present time, it is estimated that oil supplies some 43 percent of the Nation's primary energy and 97 percent of the energy used to transport people and goods. And while substitutes for oil products are under development, their widespread use will be dependent both on favorable economics and on necessary development of an infrastructure comparable to that now available for oil. Both of these factors suggest the need for secure sources of oil for at least several decades into the future.

Much has also been written on the issue of declining domestic oil production and corresponding growing dependence on oil imports. While some would argue that "the world is swimming in oil" and that our increasing dependence on imported oil is of little consequence, there appears to be a more general opinion among the public that the very security of this Nation is heavily dependent on reducing U.S. vulnerability to oil supply disruptions. Certainly the Persian Gulf crisis has heightened the sensitivity of these energy security concerns.

The gap between U.S. oil consumption and U.S. oil production, which is now being filled by imports, can only be partially satisfied by new U.S. discoveries. Even major discoveries in frontier areas such as Alaska and offshore will be unlikely to halt the decline in overall production or dramatically reverse the import dependence curve. This, then, leads to the alternative which the

DOE has wisely advanced in its April 1990 Oil Research Program Implementation Plan (ORPIP) to systematically develop the oil that remains in the ground after conventional recovery methods. This is estimated to be a resource of over 340 billion barrels of oil, or some two-thirds of the total known original oil-in-place in the United States. Much of this can be recovered with the application of EOR techniques already proven in the laboratory, advanced methods for characterizing reservoirs, and continued development of additional and improved recovery techniques.

The ORPIP is a well conceived and well documented plan which provides for immediate initiation of a structured R&D program, while at the same time containing the flexibility needed for later program modification, expansion, and detailing. Without question, it is the most comprehensive approach documented by DOE in recent years for addressing research and technology needs of the nation and of the private sector as they relate to oil production. ORPIP outlines an approach for using the Tertiary Oil Recovery Information System (TORIS) as a critical analytical tool in a program of improved recovery methods development. TORIS contains cost-shared field test information, predictive models and reservoir/geological engineering information on major domestic oil fields, historical EOR project data, and a comprehensive data base of crude oil properties.

Recognizing that the ORPIP is a flexible document that will be modified as the outlined R&D programs progress, I would like to suggest several areas for broadening the plan's applicability and usefulness to the research needs of the private sector, as viewed from our perspective at NIPER. And, again, let me make it clear that we strongly endorse the DOE-prepared ORPIP and that these suggestions relate to expansion of the plan and funded R&D activities, rather than to a change in the existing planned approach.

For the most part, the present plan is concerned with light oil only. This is the appropriate starting point, but in the face of our knowledge of known U.S. reserves, it is important to detail a comparable plan and initiate R&D activities as soon as possible related to heavy oil deposits.

Processing and refining problems associated with heavy oils and less desirable feedstocks must also be addressed. While these downstream activities are often felt to be purely a responsibility of the refiners, certain fundamental research and, specifically, thermodynamics research should be a continuing high-priority funding responsibility of the DOE. Thermodynamic measurements in the laboratory provide information about the best conditions of temperature and pressure for refinery processes that will remove harmful or problem materials from heavy crudes, in order to produce fuel products such as diesel fuel and gasoline. The thermodynamics research facility in Bartlesville, which is unmatched in the free world, provides data and research results which are of inestimable value to the petroleum industry. This capability is sufficiently broad and basic in its research role to constitute a logical element of research of the federal government, and should be directly funded by DOE at a level which insures its continued research activities and its role as a critical technical resource.

The ORPIP includes provision for field tests of EOR techniques that have been proven in the laboratory as part of the near-term and mid-term objectives, in an effort to transfer developed technology to both the major oil companies and to independent producers. In the past, DOE has often arranged for such tests to be accomplished with extensive cost-sharing from the private sector, thus effecting a very desirable leveraging of taxpayer dollars. Cost-sharing ventures may be more difficult to arrange in the future as a result of research budget cutbacks within the industry. Benefits of this kind of technology transfer should also apply as broadly as possible to small independent producers. We feel that DOE's posture with respect to funding EOR field tests should be flexible enough to allow participation by small independent producers where, for example, the in-kind value of producing properties might be the only requirement for cost sharing participation. Even if the actual number of tests would have to be reduced using this approach, the urgent requirement for transferring the technology, particularly from the view of independent producers, would justify such a compromise.

Commercialization of technology developed within DOE's oil and gas research program should continue to be a priority issue, and the ORPIP lays the foundation for such commercialization in its defined objectives for near-term and mid-term programs.

Even though the mission of DOE's oil and gas research program in the past was basically confined to long-range, high-risk research and development objectives, extensive technology transfer activities have been occurring, often with little or no fanfare. For example, Attachment 1 to this Statement lists a total of 25 significant technology transfer activities or events in the last several years that resulted from the research program at NIPER. Similar technology transfer is part of the ongoing activities of other organizations as well.

DOE has wisely maintained a level of long-range enhanced oil recovery techniques research, even though we witnessed dramatic retrenchments in R&D expenditures and capabilities by major oil companies during the past five years. Because of those continued efforts, technology is now available for further testing and transfer to the private sector as outlined in the ORPIP. Based upon numerous public meetings conducted by DOE related to formulation of the National Energy Strategy and the Oil Research Program Implementation Plan, there has been a very positive change in the relationship between the petroleum industry and DOE. Recognition of common research and technology objectives will lead to much improved opportunities for cooperative research projects among large private sector companies and with the federal government.

The direct benefit of such cooperative projects to the smaller, independent producers is much more difficult to assess. The DOE has aggressively searched for optimum methods of assisting these many small, but vitally important, components of our oil production industry; and the search must continue as part of DOE's future program. Certainly, there is a need to translate results of tests and programs outlined in the ORPIP into terms and techniques useful to the small producer for increasing what is often already marginal production. States and research organizations such as NIPER can play a large part in this interactive role with the independents in programs that are cooperatively designed and funded with DOE. Funding should be included within the DOE fossil energy R&D budget for detailed planning and conduct of such a program.

With respect to the overall R&D approach outlined in the ORPIP, it is considered essential to assure that planned scheduling and funding of long-term and fundamental research efforts that are needed to advance technology are not compromised by the urgency of near-term and mid-term research efforts. We must adopt an aggressive and consistent posture with respect to R&D funding that allows continuation of long-term research efforts while also engaging in those short-term and mid-term technology transfer efforts delineated in the ORPIP. We must engage in a very proactive program of technology transfer. But we must also guarantee that new technology will continue to be developed and available for transfer in future years.

The reason we can even plan a program of near-term and mid-term technology transfer today is because of the R&D efforts funded in previous years by DOE which at that time were thought of as fundamental or long-term R&D. The Microbial Enhanced Oil Recovery (MEOR) program carried out at NIPER is a good example of this forward thinking by DOE. Often looked at in the past as a far-out approach with questionable practical value, it is recognized today as a very promising EOR approach, especially for the small independent producer, because of its very favorable economics.

To achieve the necessary short-term and mid-term goals of the ORPIP and also to carry out its long-term objectives without mortgaging the future of advanced production technologies, DOE funding of the oil research program should be increased to the level where implementation of near-term and mid-term goals have no impact on the long-term R&D program. This magnitude of increased funding does not appear to exist in the budget request as submitted.

In this same connection, it is also considered important that there be no impact on the university and science education programs funded by DOE, including those related to advanced extraction and process technology, enhanced oil recovery, and associated environmental issues. Not only are these programs critical to the development of future technologies that result from fundamental R&D efforts, but they also provide the well-trained professional staff that assures a viable industry and viable research program for the future in both the private and public sectors. The Secretary of Energy has wisely stressed the importance of education in assuring the nation's future energy security and place in the world energy picture. The DOE-funded programs at universities are a critical component of that assurance.

I will not address the area of alternative fuels, except to note that this is an activity receiving widespread attention within the auto industry, by the oil industry, and by the DOE. NIPER is also extensively involved with testing activities in this area. Widespread adoption of alternative fuels will be dependent on supplies, on the infrastructure of distribution systems, and on environmental considerations, primarily vehicle emissions. The considerable time needed to develop and make those fuels available will no doubt mean a continued reliance on petroleum products in the U.S. transportation sector for several decades to come. Thus, the importance of increased domestic production, enhanced recovery techniques, and increased federal R&D expenditures in the oil program during the next several years is not affected by alternative fuels initiatives.

Finally, there is the issue of environmental concerns and the place in the Fossil Energy program for such environmental considerations. Clearly, the National Energy Strategy includes a commitment to a safer and healthier environment. And, with respect to oil production, processing, and utilization, that includes concerns for protection of environmentally sensitive areas, exploration and production wastes, emissions from all sectors of the industry, and oil transportation accidents.

The petroleum industry is operating in an era of heightened environmental concerns today. Emotionally charged feelings and conflicts are sometimes present in the search for a balance between environmental sensitivities and energy availability. Problems associated with some oil production activities, such as sludge pits, are well known. But practical solutions are not always so obvious. Additional R&D is often required to generate data needed to assess impacts and to arrive at rational disposal or cleanup approaches, rather that to derive solutions based on emotion. Such R&D costs time and money; but in the long run, it can avoid restrictive legislation and regulations that burden the economy with hidden costs and affect international competitiveness.

Environmental R&D associated with oil supply, transportation, and use is a very logical element of the DOE Fossil Energy research program and is expected to grow in significance with time. Many of the capabilities developed for enhanced oil recovery and reservoir characterization are directly applicable or easily translatable to this effort, as evidenced by environmental project work at NIPER. In particular, this applies to the EPA program for Underground Injection Control for Class II (oil- and gas-related) wells and to reservoir knowledge required for deep well injection of hazardous wastes. In addition, certain emulsifiers and microbial formulations developed in the NIPER laboratories have the potential for being successfully applied to cleanup of on-shore and off-shore oil spills.

Even before President Bush formally unveiled his long-term energy blueprint last month, the newspaper headlines were predicting "domestic battles" over the formal energy policy, especially with regard to issues of more energy conservation versus increased domestic production. Numerous bills have already been introduced which, according to one report, are "so varied that no compromise will come easily."

It should be obvious that this is not a time in our nation's history for battle between conservationists and those advocating increased production. We must do both. It is foolish to think that there is a way to avoid stricter energy conservation measures in the long-range future. It is equally foolish to think that increased domestic production of oil and gas is not a long-range priority matter for this nation's economic health, energy security, and survival. We must guard against the temptation to think only of short-term issues and advantages with respect to formulating energy policies. We must project our needs and our priorities for the next decades -- and we must plan our research strategies and our research funding accordingly. There can be no doubt that both increased energy conservation and increased domestic energy production will emerge as necessary, high-priority policies in such long-range planning.

I make the following recommendations related to the FY 1992 budget request:

- Significant increases in funding for R&D in petroleum production technologies such as enhanced oil recovery and geosciences should be provided to stimulate development and application of current and emerging technologies. DOE's programs in basic research, which provide the basis for development of advanced technologies, must be maintained. Additional funding is needed to implement field demonstration projects and applied R&D to advance currently promising technologies to commercialization. **I recommend that budget allocations for DOE's Fossil Energy Research and Development in enhanced oil recovery be increased by 50% to $48 million to provide funding for research needed to accelerate development and application of technologies that will increase our domestic oil production. A similar level of increase should be provided to support development of advanced extraction and processing technologies.**

- The scope of the ORPIP should be broadened to address heavy oil as well as light oil. A detailed plan should be developed that will provide for utilization of our nation's heavy oil resources. This should include elements addressing enhanced oil recovery methods as well as processing and refining for heavy oil. **Federal funding for the thermodynamics research activities at NIPER in Bartlesville should be provided at a level sufficient to maintain this critical capability.**

- Funding should be authorized for an R&D program to assess the impact of petroleum production, refining, and distribution on our environment and to develop technically-based solutions to problems that are identified. As the government agency most familiar with the diverse aspects of oil and gas production, processing, and transportation, DOE should play a proactive role in concert with other government agencies and with industry trade associations in working together to find solutions to environmental problems that are based on sound technical facts. **I recommend that funds be specifically authorized within DOE's Fossil Energy budget for research and development and for cooperative activities with industry and government agencies to address the environmental impact of petroleum production, refining, and distribution.** I further recommend that a portion of these funds be designated to provide information and assistance to independent operators in complying with mitigation requirements of stringent environmental regulations associated with oil and gas exploration and production.

## EXAMPLES OF TECHNOLOGY TRANSFER/COMMERCIALIZATION

### IIT Research Institute
### National Institute for Petroleum and Energy Research

- Under DOE's sponsorship over several years, IITRI researchers have developed a unique automated X-ray/microwave apparatus for measuring two- and three-phase relative permeabilities under unsteady-state and steady-state conditions at extreme reservoir conditions. Relative permeability data are used by the petroleum industry for designing recovery processes and as input for computer simulation. A patent application on this novel apparatus has been filed and an equipment manufacturer is currently marketing an apparatus based on NIPER's design to industrial clients. The commercial vendor is also using software for automation of the apparatus that was developed by IITRI at NIPER. IITRI personnel have trained staff members from companies that have purchased the apparatus from the commercial vendor.

  The unique apparatus that was developed by IITRI at NIPER has impacted commercial operations by major oil companies through applications on numerous projects. Selected examples of prior projects that impacted commercial operations are summarized below.

  - The apparatus was used to determine effects of waterflooding on formation damage for a reservoir in South America. The results of the NIPER study resulted in the waterflooding project not being implemented due to the significant degree of formation damage that was observed.

  - The apparatus was used to design production strategies for a major condensate reservoir. The critical condensate saturation was determined at reservoir conditions to determine the decline in productivity that would occur under various production strategies.

  - A variety of projects have been conducted for major oil companies that have impacted development and production strategies for major onshore and offshore reservoirs including a deep gas reservoir in the Gulf of Mexico, an offshore reservoir in China, a carbonate reservoir in which a miscible flood is being planned, and numerous other applications that can not be mentioned due to restrictions with respect to client confidentiality.

  - IITRI conducted waterflood feasibility study in a low-permeability reservoir in China that contained a high-viscosity crude oil. Based on the results of the IITRI study, a large-scale waterflood was implemented.

- IITRI has patented technologies for microbial enhanced oil recovery applications. IITRI has worked with both the U.S. Department of Energy and independent producers to conduct cost-shared field demonstration projects of microbial-enhanced waterflooding. One project was successfully completed in Nowata County, Oklahoma and a second, larger-scale project is currently in progress in Rogers County, Oklahoma. This is an excellent example of how IITRI has conducted basic research to develop and patent a technology, applied research to design microbial formulations for specific applications, and finally implemented the method in field applications.

- IITRI has patented a technology for surfactant-enhanced alkaline flooding. A cost-shared field project to demonstrate the technical and economic feasibility of applying this technology has recently been initiated. IITRI was also retained by a major oil company to design a surfactant-enhanced alkaline flooding system for application in a carbonate reservoir in Texas.

- IITRI has patented an improved method for steamflooding. This invention relates to a novel protocol for enhanced oil recovery by steamflooding that helps to improve oil recovery.
- IITRI has developed a number of computer simulators that are now being used in the petroleum industry by major oil companies and independent producers. Some of the software packages that are currently available are: (1) **BEST** - a general-purpose black oil simulator, and **BEST-VHS** - a vertical/horizontal/slant well simulator. These simulators are available for both mainframe and personal computers so that both major oil companies and independent producers can use them. IITRI has conducted studies using **BEST-VHS** to predict production potential in fields where operators have drilled horizontal wells after consideration of the simulation results.
- As part of a major project on a tight gas reservoir in China, IITRI researchers conducted highly specialized laboratory tests to design well stimulation techniques including hydraulic fracturing and acidizing that have been successfully implemented in the field.
- NIPER developed a crosslinking system for a powdered biopolymer product under joint sponsorship of the DOE and a major chemical company. This method has been successfully tested by an independent producer in Kansas for water shut-off.
- NIPER has developed a novel mobility control technology that is currently being patented by an industrial client.
- NIPER's Biotechnology Group has provided testing and training in specialized techniques for evaluating biocides to a major chemical company.
- NIPER currently provides laboratory and consulting services in testing of plastic materials to a plastic manufacturer.
- Under contract to Pantex, a major DOD weapons contractor, researchers at NIPER applied our unique expertise in heat conduction calorimetry to develop a new technique for testing plastic-bonded explosive materials.

Many of the technologies that have been developed by IITRI at NIPER have been transferred to industry through symposia, training programs, and short courses organized and conducted by IITRI staff members. Selected examples are summarized below.

- Organized Symposium on **Applications of Microorganisms to Petroleum Technology** in Bartlesville, OK on August 12-13, 1987. This symposium was sponsored by the U.S. Department of Energy, IIT Research Institute/NIPER, IPAA, OIPA, KIOGA, and IOGA. More than 120 interested persons attended the conference from 14 states including the major oil producing states of Texas, Oklahoma, Kansas, California, Illinois, Colorado, and New Mexico and from four foreign countries including Australia, Japan, Canada, and the United Kingdom. Representatives from four domestic and two foreign major oil companies also attended. Proceedings of this symposium, which was published by the DOE, consisted of 19 technical articles by authors from the U.S. and 7 foreign countries. This conference did much to stimulate interest in microbial enhanced oil recovery technologies.
- Conducted Short Course on **Improving Oil Recovery By Use of Microorganisms** in Bartlesville, OK, August 11, 1987. More than 100 persons attended the one-day short course.

- Conducted Short Course on **Use of Microorganisms To Improve Oil Recovery** at the Illinois Oil and Gas Association Fall Meeting in Mount Vernon, Illinois, September 25, 1987. More than 45 independent producers, mostly from Illinois, attended this one-day short course.

- Conducted Short Course on **Microbial Enhanced Oil Recovery** for independent oil producers in Bartlesville, Oklahoma, May 23, 1989. More than 55 persons attending this comprehensive short course.

- Conducted Short Course on **Special Reservoir Characterization Needs for Application of Enhanced Oil Recovery** at the Second International Reservoir Characterization Technical Conference in Dallas, Texas, June 25, 1989. More than 100 people attended this short course.

- Organized **First International Reservoir Characterization Technical Conference** in Dallas, Texas, April 29-May 9, 1985, which was cosponsored by the U.S. Department of Energy. This initial conference was a pioneering effort to bring together researchers from many diverse backgrounds who were working in various areas of reservoir characterization research. More than 130 persons attended the conference from the U.S. and many foreign countries. A 659-page book was published by Academic Press that contained the proceedings of this important meeting and the book was reprinted to meet the continuing demand.

- Organized **Second International Reservoir Characterization Technical Conference** in Dallas, Texas, June 25-28, 1989, which was cosponsored by the U.S. Department of Energy. This second conference focused on understanding heterogeneities at various scales ranging from microscopic to field scales. More than 240 persons attended the conference from the U.S. and many foreign countries. A 704-page book is being published by Academic Press that contains the proceedings of this meeting.

- Under cosponsorship of the U.S. Department of Energy, NIPER is currently organizing the **Third International Reservoir Characterization Technical Conference** which will be held in Tulsa, Oklahoma November 3-5, 1991. This conference continues to be an outstanding example of NIPER's efforts to foster cooperation between researchers in this field and to assist in transferring technology that is being developed under DOE sponsorship both at NIPER and other organizations to the oil and gas industry.

- IITRI has conducted training courses ranging from several days to more than one year for various industrial clients from Japan, Malaysia, China, India, United Kingdom and Venezuela. The training courses have included class room instruction and hands-on training in laboratory procedures and equipment design.

- IITRI researchers presented 7 papers at the SPE/DOE Symposium on Enhanced Oil Recovery, which was held in Tulsa, Oklahoma, in April of 1989. This is the greatest number of technical papers that have ever been accepted for presentation from one organization at this prestigious meeting since its inception.

- IITRI has hosted university professors at NIPER under DOE's historically black college and university training program. Our staff members provided training in enhanced oil recovery and thermodynamics to faculty members. IITRI has also provided training for numerous students in various areas of petroleum technology through the Associated Western Universities program.

- Since 1985, 2 years after NIPER's establishment, professional society journals and industry trade journals have published annually an average of some 50 technical papers and articles by IITRI authors reporting on results of research conducted at NIPER. These articles are in addition to the proprietary IITRI reports on research results prepared for industrial clients and the DOE.

- IITRI professional employees at NIPER work closely with committees of Society of Petroleum Engineers, Calorimetry Conference, American Chemical Society, American Institute for Chemical Engineers, American Association of Petroleum Geologists, Society of Core Analysts, Independent Petroleum Association of America, and other society and trade organizations, including numerous state associations of oil producers and petroleum geologists.

- IITRI maintains a close working relationship with the DOE Office of Scientific and Technical Information, Federal Laboratory Consortium, National Technical Information System, and other federal and state groups involved in technology transfer.

Mr. SMITH. Mr. Deterding, thank you very much.

Dr. Derbyshire, we will go to you next.

## STATEMENT OF DR. FRANK DERBYSHIRE, DIRECTOR, UNIVERSITY OF KENTUCKY, CENTER FOR APPLIED ENERGY RESEARCH

Dr. DERBYSHIRE. Thank you, Mr. Chairman and members of the subcommittee. For the record, my name is Frank Derbyshire of the University of Kentucky Center for Applied Energy Research.

My testimony concerns the continuation of research and development for Eastern oil shale, for which we are requesting $26 million for a three-year program from 1992 to 1994. I would also like to comment on some particular issues which concern broader aspects of fossil energy research and development.

As we all know, the U.S. economy is very heavily dependent upon the availability of imported petroleum. Since 1983, domestic production has decreased by about 16 percent, and over the same period imports have risen by about 56 percent. Estimates show that by the end of the century, imports will represent somewhere between 60 to 70 percent of total consumption. And the recent events in the Gulf which we have all been referring to have again brought to focus the very fragile nature of this dependence.

We obviously have to take some steps to reduce consumption and also to generate alternative fuels from domestic resources. Coal and oil shale are two of the most important indigenous fossil fuels. However, the Department of Energy funding recommendations are not commensurate with the importance of these particular resources. The funding request for oil shale research is effectively zero. It has been reduced by 60 percent for coal liquefaction, by 64 percent for coal gasification, and by 60 percent for coal cleaning. Once more it has been left to Congress and others to formulate and support a rational, balanced fossil fuel program.

First, with respect to Eastern oil shale research and development. This resource is large, it is estimated to contain over the equivalent of 400 billion barrels of oil. Over the last decade we have improved our understanding of its characteristics and been able to create new processing concepts and technologies. Recent estimates have shown that oil can be produced for about $35 per barrel by advanced technologies, which is similar to the cost estimates for advanced coal liquids, and somewhat lower than for U.S. Western Oil Shale.

The development of the Eastern shale resource is also favored by an existing infrastructure, which is well developed. In addition, the shale deposits are close to existing coal fields, where there is a well trained and underemployed work force. Processing the shale can deliver a range of products which lowers the economic risk and the first commercial plants could be small, which is certainly an incentive to attracting private investment.

Finally, the Eastern shales are primarily composed of silicate rocks, which produce far less carbon dioxide when heated to retorting temperatures than the carbonate shales of the West. Research on Eastern shale has been focused at the University of Kentucky and universities in Alabama, Tennessee, Ohio, Illinois and at the Institute of Gas Technology.

Since 1982, at the University of Kentucky we have been developing a retorting technology designed specifically for Eastern oil shale. It produces enhanced oil yields, provides heat to drive the process, and generates valuable by-products in the form of a hydrogen-rich gas and sulfur as well as the oil.

From 1982 to 1986, the development of this technology was funded entirely by the State of Kentucky. Since then, through cost shared contracts with the Department of Energy, we have progressed to the development of the 1,200 pounds per day process, which will operate under conditions close to those of a commercial unit. Over the next three years we will be evaluating this process and using the data to determine the feasibility and economics of constructing a pilot plant.

The process has been shown to be applicable to other shales, as we recently demonstrated by successfully retorting a Brazilian shale. This showed that the Eastern oil shale technologies cannot only improve our domestic energy base, but also result in an exportable technology. We have also developed a better understanding of the fundamental nature of the organic matter in the shale, and found that different shale types produce different amounts of oil and gas. We propose that a regional resource evaluation should be initiated to better characterize this resource in the light of our recent technical advances, and used as information to formulate a strategy for its development.

Compared to the United States, other nations are more supportive of oil shale development. There are large scale retorting processes currently being developed in Brazil and in Australia, and other research and developments are in existence in Israel, Morocco, Turkey, the Soviet Union and China. In this particular context, it is apparent that the issues presented by the continuing need to develop fossil fuels have an international character. We feel we could profit considerably from developing interactions with organizations which have similar interests.

Apart from existing affiliations we have developed in the United States, we are also developing research initiatives with scientists in Australia and the United Kingdom and other ones are being contemplated.

The failure of Occidental Petroleum's development last year shows the danger of a program that is based on a single technology that is focused on a single resource and is led by a single company. Using this as an example, what we really need to have is a stable, well-balanced program of energy research and development which has the objectives of broadening our energy base and expanding our options.

A further important point, I feel, is that significant progress that has already been achieved is a direct consequence of the commitments made by Congress and by individual states. The gains made through this investment are certainly going to be lost if the work cannot be sustained and brought to some point of fruition.

For the fiscal period 1992 to 1994 we support a program of $26 million for Eastern oil shale research, which includes $4.5 million for scaling up the Institute of Gas Technology's retorting process; $10 million for technology based activities relating to the processes under development at the Institute of Gas Technology and the University of Kentucky; $3 million for Eastern oil shale resource assessment and environmental studies, which will be coordinated by the University of Kentucky; and $.5 million for an economic assessment and pilot plant development study for the University of Kentucky's technology in financial year 1994.

I would like to briefly move on to a few other issues in energy research and development and stress some selected problems in the areas of coal liquefaction, coal cleaning, multi-institutional collaboration, cost sharing and education and training.

In coal liquefaction, the Department of Energy's strategy is to reduce the cost of coal liquids to between $25 to $30 a barrel. Laboratory scale work has already produced a number of concepts which could contribute to this objective, and we feel that this valuable work should be continued.

On a larger scale, there has also been considerable progress in process and engineering developments. The Wilsonville Plant, where most of this has taken place, is now the only available test bed where new ideas can be evaluated on any scale which provides meaningful and credible data. This success is certainly not going to continue if the funding is reduced by 60 percent, as recommended by DOE.

In clean coal, the Clean Coal Technology Demonstration Program has assisted clean coal technologies to progress from laboratory to pilot and demonstration scale, which is very commendable. At the same time, basic coal cleaning research has been deemphasized. This is certainly going to create a hiatus in the development of the next generation of technologies. We feel that a more comprehensive program should be supported which brings basic, as well as applied, research into focus.

Third, the importance of optimizing expertise through cooperative associations between universities, industry and national laboratories has become much more broadly recognized than in the past. We feel funding policies should continue to be supportive of this type of interactive research and to implement measures which facilitate its propagation.

Number four concerns cost sharing. This is a particular concern which is being proposed for various research programs. I feel a strong financial commitment from participating organizations is reasonable for those technologies that are close to maturity. For long-term projects these requirements will certainly prevent or deter participation. The whole history of alternative fuel technology where we have examples—Germany, South Africa, and to some extent Japan—clear shows that success is only achieved when governments have been prepared to make a long-term investment and commitment, to the point where the elements of cost and risk become more acceptable to private investors.

Last, I would like to draw the subcommittee's attention to perhaps the single greatest obstacle to development of indigenous fossil fuel resources, and that is the inadequacy of the resource of qualified and experienced people. The real hidden energy crisis is the shortage of capable young scientists and engineers in fossil energy research and development. We have a very urgent need for recruitment, education and training. Federal sponsorship could assure the establishment of graduate programs in fuels science and technology at a number of universities. Longer term measures would be to institute degree courses to bring those same elements of learning to the high schools.

The University of Kentucky is one of a few universities with a long tradition of education and research in fossil energy and is very well positioned to address these needs. The pattern of expenditure cuts proposed by the Department of Energy will exacerbate these problems in recruitment and education, as they first affect outside contracts which include universities, then projects at national laboratories, and finally the energy technology centers. This type of strategy is devastating to universities, particularly, where stable funding is essential for the maintenance of quality programs.

To summarize, I believe there should be a well-planned, balanced and stable budget policy to support the development of technologies for the clean use of domestic resources of oil shale and coal. This has been the policy of the U.S. Congress for the past decade, and I hope it will be continued.

Specifically, we request continuing support for the development of Eastern oil shale; fundamental research and larger scale process development in coal liquefaction; basic and innovative research in coal cleaning; further promotion of interactions between universities, national laboratories and industry; and finally, implementation of graduate and undergraduate education and training programs in fuel science and technology.

Thank you.

[The prepared statement of Dr. Derbyshire follows:]

Testimony on Eastern Oil Shale and Coal Research
Subcommittee on Energy
Committee on Science, Space and Technology
U.S. House of Representatives
March 14, 1991

By
Dr. Frank Derbyshire, Director
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## Introduction

Madam Chairman and members of the Subcommittee. My testimony addresses the Department of Energy's budget request for fossil energy research and development for the fiscal year 1992. In particular, I would like to present to the subcommittee considerations which support the continuance of research and development of Eastern U.S. oil shale, for which we request $26 million for the period FY 1992 to FY 1994. I will also comment on some of the broader issues relevant to fossil energy research and development, with specific emphasis on coal.

The economies of the U.S. and other industrialized nations are heavily reliant upon petroleum availability and cost. Our petroleum consumption is the highest in the world and cannot be satisfied by domestic production, which is in continual decline. The balance is supplied by imports, primarily from the Middle East. Recent events in the Gulf have brought to focus once again the fragile nature of this dependence. Domestic oil production was estimated to average 7.3 million barrels per day (BPD) in 1990, approximately twenty percent lower than the 1983 average of 8.7 million BPD. Over the same period, imported oil has risen from 5.1[1] million BPD to an estimated 8.0 million BPD, an increase of 56%. This trend will continue and it is estimated that, by the end of the century, imports will have risen to 60 to 70% of our total consumption.

In the future, there will be further demands upon the available supply of petroleum. Currently, the OECD[2] countries consume 37 million BPD or about two thirds of the world's production of 60 million BPD. This figure has held essentially constant for the past decade, but the situation will not continue indefinitely. The OECD represents less than a third of the world's population. Developing economies in Eastern Europe and third world countries will create a growth in energy consumption and greater competition for petroleum resources.

The inescapable conclusion is that the U.S. must take steps to reduce consumption and to generate alternative fuels from indigenous resources. The development of appropriate technologies can alleviate our strategic and economic vulnerability and provide a realistic cap on world oil prices.

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[1] *Crude oil plus finished petroleum products.*

[2] *Organization for Economic Cooperation and Development, which consists of the U.S., Canada, Japan, Australia, New Zealand and the European Community.*

The statements from U.S. DoE, which accompanied their budget recommendations to Congress, conclude that coal is America's most important indigenous fossil fuel and that oil shale is our best prospect for long-term energy security. Unfortunately, funding recommendations are not commensurate with these statements. The funding request for oil shale research is effectively zero. It has been reduced by 60% for coal liquefaction, by 64% for coal gasification, and by 60% for coal cleaning. It is again left to Congress and others to formulate and fund a rational balanced fossil fuel program.

## Eastern Oil Shale Research and Development

Eastern oil shale is an energy resource of immense potential, estimated to contain the equivalent of more than 400 billion barrels of oil. Over the past decade, we have greatly increased our understanding of its processing characteristics. This has resulted in the creation of more efficient technologies, based upon new processing concepts, which will lower development costs and the cost of oil produced.

Recent estimates show that oil can be produced from Eastern oil shale for $35 per barrel, utilizing an advanced fluidized bed technology similar to one which we are developing at the Center for Applied Energy Research. This is $2 per barrel less than for oil from Western oil shale and comparable to that for liquid fuels from advanced coal liquefaction and mild gasification technologies.

Other economic, sociological and environmental factors favor Eastern oil shale development. The Eastern U.S. has a well developed infrastructure which will facilitate commercial development. The first plants could therefore be small. The shale deposits are near existing coalfields where there is a well-trained and underemployed work force. In addition, Eastern shale can deliver a broad range of products such as high- and medium-heating value gas, specialty chemicals, sulfur and surplus power, thus providing operational flexibility and lowering economic risk. For these reasons, the development of Eastern shale will entail less capital risk than other alternative fuels and be more attractive to private investment. Finally, Eastern oil shales are silicates which produce far less $CO_2$ than the carbonate shales of the Western U.S.

## Research Progress

The CAER has been developing the KENTORT II retort technology, since 1982. This technology, which uses an atmospheric pressure multi-staged fluidized bed process to produce enhanced oil yields and provide heat to drive the process. In addition to oil, the products include a medium heating value, hydrogen-rich gas which can be used to upgrade the oil or as a feedstock for methanol production. Most of the sulfur in the shale is removed in a form which can be processed to elemental sulfur, a by-product of increasing value.

From 1982 to 1986, research and development on this process was supported entirely by funding from the State of Kentucky. In 1986 we entered into a three year agreement with the U.S. Department of Energy to conduct a more extensive research and development program utilizing a process miniplant with a capacity of 120 pounds per day of shale. This research effort proved the viability of the KENTORT II concept by overcoming key engineering problems.

Over the past year, there has been significant progress in advancing the new technologies and in expanding the understanding of the chemical nature of the resource. In addition to the research at the University of Kentucky Center for Applied Energy Research (CAER), substantial progress is also being made in other organizations involved in Eastern oil shale research, including universities in Alabama, Tennessee, Ohio and Illinois and at the Institute of Gas Technology.

Other work has demonstrated the general applicability of the process to other shales. Eastern oil shale is considered to be similar to most of the world's other oil shale deposits. Last year, with help from the Petrobras oil company, we conducted a study on processing the Irati oil shale of Brazil. Our retort performed extremely well, producing 29 gallons/ton of shale oil compared to about 22 gallons/ton for Petrobras' PETROSIX technology. The results from the Irati tests indicate that Eastern oil shale research can not only improve our domestic energy base, but also result in exportable technology.

In September of 1990 we entered into a second agreement with the U.S. DoE to scale up the process and construct a 1,200 pounds per day process development unit. This unit will operate under regimes close to those of a commercial unit and will lay the technical foundation for pilot scale development and economic evaluations. The State of Kentucky, through the University of Kentucky, is sharing this cost on almost a dollar for dollar basis with the U.S. DoE.

Substantial progress has also been made in more fundamental areas of Eastern oil shale research. Last year, we continued to improve our understanding the fundamental nature of the organic matter in Eastern oil shale. This material is more complex than Western oil shale, and contains four major components. Each of these components produces different proportions of oil and gas and each is subject to regional and stratigraphic variation. The distribution of these organic types will affect resource development strategies for Eastern oil shale.

**Initiatives in Fiscal Years 1992 to 1994.** During the next three years, we will evaluate the KENTORT II process on the increased scale and include work with foreign oil shales that are compatible with the technology, such as the Irati. By mid FY 1994 we will have completed the test series and made an economic assessment. The data will be employed to determine the feasibility of constructing a pilot plant as a domestic venture and/or with foreign investment and collaboration.

Eastern oil shale is an enormous and important resource. In a reconnaissance study, the U.S. Geological Survey found shale equivalent to more than 400 billion barrels of oil as measured by the Fischer Assay method, with another possible 2,600 billion barrels of shale from the extension of known deposits. However, Eastern oil shale is distributed over a wide geographic area and contains a variety of oil shale types and grades. A resource development strategy is needed to target the best areas.

During the early 1980's, the states of Kentucky, Indiana, Alabama, Tennessee and Ohio, as well as the Institute of Gas Technology, conducted public domain resource assessment efforts. These efforts should be built upon and augmented. We propose a regional Eastern oil shale resource evaluation to characterize the resource in light of recent advances in understanding its chemistry and the advent of new retorting technologies. The information will be integrated into the national oil shale data base.

## International Oil Shale Developments

Compared to the U.S., other nations are more optimistic and supportive of oil shale development. Three years ago Petrobras of Brazil, decided to construct a 36-foot diameter, 3600 BPD PETROSIX retort. This retort will come on-stream in November of 1991. They believe economic interests, including the support of industries which have grown up around the oil shale plant, as well as future energy supply and costs, will ultimately justify this commitment.

In Australia, the Southern Pacific Petroleum Company continues to develop the Stuart Oil shale deposit in Queensland as construction plans for a 4,250 BPD commercial-demonstration plant proceed. Other examples include a 41 MW oil shale fired power station in Israel and research and development efforts in Morocco, Turkey, the Soviet Union and China.

In this context, it is apparent that the issues presented by the continuing need to use fossil fuels are shared internationally. There is a limit to the national resources that can be invested in Research and Development and considerable advantage can accrue from effective interaction with organizations which share similar interests. To this end, we are actively developing research initiatives with scientists at the Commonwealth Scientific and Research Organization (CSIRO) of Australia and the University of Strathclyde in Glasgow, UK. These plans include the short-term exchange of researchers. Similar personnel and information exchanges and visits are contemplated with Turkey and Israel.

Last November the 10th Eastern Oil Shale symposium was held in Lexington, Kentucky. More than 50 papers were presented on aspects of Eastern oil shale, other similar oil shales world wide and tar sands. Researchers from across the U.S. as well as Australia, Japan, the United Kingdom, Spain, Canada and Turkey presented papers. This symposium, hosted by the University of Kentucky, has grown in stature to be a highly recognized forum for the exchange of research information. The prestigious international journal *Fuel* will publish the bulk of the papers presented at the 1990 meeting in a special issue.

## Funding Recommendations

Eastern oil shale development requires new technologies with inherently lower costs, higher efficiencies and environmental performance. This is best served by a stable funding base. For the fiscal period 1992 to 1994 we support a $26 million program for Eastern oil shale research which includes;

- ☐ $12.5 million to scale up the Pressurized Fluidized Bed Hydroretorting (PFH) process at the Institute of Gas Technology
- ☐ $10.0 million for technology-based activities relative to the PFH and the KENTORT II processes
- ☐ $3.0 million for regional Eastern oil shale resource assessment and environmental studies, coordinated by the University of Kentucky Center for Applied Energy Research
- ☐ $0.5 million for an economic assessment and pilot plant development study for the KENTORT II technology in FY 1994.

The failure of Occidental Petroleum Company's Modified In Situ retort development program last year shows the danger of a national oil shale program based on a single technology, focused on a single resource and led by a single company. The U.S. needs a well balanced program of energy research and development, with the objective of broadening our energy base and expanding our options.

A further important consideration is that the significant progress that has already been achieved is the direct consequence of the commitments made by Congress and by individual states. The gains made through this financial investment will be irrevocably lost if the work cannot be sustained and brought to fruition.

## Other Energy Research and Development Issues

With regard to research and development priorities for coal, I fully endorse the statements and recommendations made on coal liquefaction and coal cleaning in the testimonies offered to the Subcommittee on March 5th, 1991 by Frank Burke, representing the National Coal Association, Gary Styles of Southern Company Services and Lawrence Wisdom of Hydrocarbon Research Inc.

One of the U.S DoE strategies is to reduce the cost of coal liquids to $25 to $30 barrel. This is a realistic goal and one which is attainable through a co-ordinated program of research. Over the past several years, there have been considerable advances on the laboratory scale in the development of concepts which could contribute to lowering the cost of coal liquids. This valuable work should be continued. Through the operation of the Wilsonville Advanced Coal Liquefaction Facility, there has also been considerable progress in process and engineering developments that have demonstrated the potential for increasing distillate yields up to 75%. The Wilsonville plant is now the only available test-bed where new ideas can be evaluated on a scale which provides meaningful and credible data. However, there is little hope for continued success on either the fundamental or applied research levels if funding is reduced by 60%, as proposed by the DoE.

An area for concern is the increasing level of cost-sharing which is being proposed for coal liquefaction and other research programs. A strong financial commitment from participant organizations may be reasonable for technologies that are close to maturity. In other long-term projects, where commercial realization is more distant, these requirements will prevent or deter participation. The history of alternative fuel technology shows clearly that success has only been achieved when national governments have been prepared to make a long-term investment and commitment to the point where the elements of cost and risk become more acceptable to private industry.

The Clean Coal Technology Demonstration Program has successfully assisted clean coal technologies to progress from the laboratory to pilot and demonstration scale. Simultaneously, there has been a de-emphasis of basic coal cleaning research which will create a hiatus in the development of the next generation of coal cleaning technologies. A more comprehensive program should be supported which addresses basic as well as applied research. Again, there is no expectation that this will be realized by the DoE's recommended reduction in funding for coal preparation research.

The importance of optimizing the nation's pool of expertise in fossil energy research and development through co-operative associations between universities, industry and national laboratories is beginning to become more broadly recognized. The CAER has entered into collaborative proposals and agreements with Amoco Corporation, Consolidation Coal Company and Sandia National Laboratories and we have sponsored meetings and workshops to provide a forum for the exchange of ideas between organizations. We will pursue such interactions wherever these are deemed to be of benefit to our research mission and strongly recommend that funding policies continue to be supportive of collaborative research and to implement measures which facilitate its propagation.

Last, I wish to draw the Subcommittee's attention to perhaps the single greatest obstacle to the development of indigenous fossil fuel resources and that is the inadequacy of the resource of qualified and experienced people. The hidden energy crisis is the lack of scientists and engineers in energy research and development. The cyclic nature and uncertainty of support in alternative energy R & D has contributed to a chronic shortage of young people who are involved in and attracted to this field.

Presently, there is a only a small and diminishing community of ageing fuel scientists. There is an urgent need to recruit, educate and train young U.S. scientists and engineers in energy research and development. Federal sponsorship could ensure the establishment of graduate programs in Fuel Science and Technology at a number of universities. These programs could draw upon graduates from a range of conventional disciplines. Longer term measures would be to institute degree courses and to bring the elements of learning to high schools. The University of Kentucky is one of a few universities with a long tradition of education and research in fossil energy and is uniquely posed to address these needs. The development of multi-institutional programs, which I discussed above, could lend tremendous support to this endeavor by exposing graduate and undergraduate students to the best and most advanced thinking, providing high quality experiential training, and helping to attract quality students.

The impact of the U.S. DoE budget recommendations to Congress will be to exacerbate the problems of recruitment and education. The pattern of expenditure cuts will first affect outside contracts, then projects at the National Laboratories, and finally in-house work. This strategy is devastating to universities where stable funding is essential for the maintenance of quality programs.

## Energy Research Recommendations

To summarize, I believe that there should be a well-planned, balanced and stable budget policy to support the development of technologies for the clean use of domestic resources of oil shale and coal. This has been the policy of the U.S. Congress during the past decade and we hope it will continue. Specifically, we request continuing support for:

☐ the development of Eastern oil shale ($26 million from 1992-1994)

☐ fundamental research and larger-scale process development in coal liquefaction

☐ basic and innovative research in coal cleaning

☐ the further promotion of co-operative interactions between universities, national laboratories and industry

☐ the implementation of graduate and undergraduate education and training programs in Fuel Science and Technology

**Mr. Bruce.** Dr. Burchfield?

**Dr. Burchfield.** I am accompanying Mr. Deterding.

**Mr. Bruce.** Well, I surprised you, didn't I?

I thank the panel for your testimony, and at this time I would like to ask unanimous consent for my opening statement and any other members' opening statement be entered into the record into this point. Is there objection?

Without objection.

**Mr. Bruce.** Mr. Hyde, my question to you would be, there is concern—I come from the State of Illinois. I have many, many independent and small producers. In your testimony, you recommended ventures to bring Federal oil and research programs to small producers.

Can you give us some recommendations on how a joint venture program between small producers would be structured to receive the most benefit from Federal dollars? What do you expect the joint ventures—how would you cost share that with independent producers?

**Dr. Hyde.** Thank you, Mr. Bruce. the fundamental way in which a program of joint ventures will work with the independents I believe to be one which involves the independents at the earliest stage of the effort to transfer the technology. They must be able to be involved in the planning. They will move ahead on their own as they see the benefits of some of the technologies that are available to them.

But they are looking at the entire oil and gas industry programs from a different perspective than perhaps you or I are looking at them. They are looking at the economic side, strictly dollars and cost. They assess risk every day, and they will assess the risk associated with such a technology transfer program.

If we let the Department of Energy be a catalyst for this kind of cost shared joint program, or joint venture, for the industry, and let the men in the industry, independents—but we have to be careful when we address the word independent. It means quite a number of different things to different people.

**Mr. Bruce.** Mainly I'm thinking about my people.

**Dr. Hyde.** Okay. We have very small independents, with 40 or 50 barrels of oil per day, and very large independents that have $10 million or $20 million drilling programs. There is a great deal of interest in the programs that have come out of Kansas for the Tertiary Oil Recovery Program, where the independents have joined together attacking a particular technology, and getting that technology going on the ground, and sometimes these technologies are those that already exist.

So I believe fundamentally that the support needs to come as a mentor type of relationship, to provide the mechanism for the independents to come together. Once they have that incentive coming from the Federal Government—because currently, at least in Texas, they just don't know where to go. They are either not aware of the technology, or not aware of how to put together tertiary fields. Not aware. Not many of them have the technical capability, or the scientists and engineers to deal with some of it, even if it is available. This would include areas such as 3-D seismic, and horizontal drilling. They have the fields they want to buy, they wish to put together into various large scale programs. But they can't get hold of the technology, because sometimes it is held by the majors.

Mr. BRUCE. I am just curious, you say we should consult with them. I represent a three State area, Illinois and Indiana and Eastern Kentucky, where we have significant oil production. My guys are small guys, and they are all independent, not only independent, but independent cusses, a lot of times. How do you ask them or get them involved in Texas?

Dr. HYDE. It comes from the larger independents. For example, the drilling programs came out this year, just recently, for both the majors and the independents, and in West Texas, the largest drilling activity that will be undertaken will be done by Texaco, the second largest activity will be done by an independent. The larger independents have the resources. Through their leadership, they will pull the smaller ones right alone with them. I feel that is the way the industry is structured, and that's the way the gentlemen in the industry work.

Mr. BRUCE. Dr. Derbyshire, you indicated there was a sulfur by-product of some of your shale operations. What is that by-product and what is the market for it?

Dr. DERBYSHIRE. It is removed as hydrogen disulfide and then converted to elemental sulfur. That in fact is a fairly important industrial feed stock. It goes into things like pharmaceuticals, acid production, sulfuric acid, fertilizers, it tends to underwrite a lot of processes in the chemical processing industry.

Mr. BRUCE. I have a lot of high sulfur coal and a lot of scrubbers that remove that very product, but we don't find a lot of commercial value in it, because as we have been able to extract it from the coal, there is a surplus of sulfur. To refine it, the refining costs to get it into a grade that is marketable, at that point the market price is below our cost in the sulfur. Do you have something different in shale production that I am not aware of?

Dr. DERBYSHIRE. In combustion, you are releasing the sulfur as an oxide of sulfur, which is much more difficult to convert. This particular technology, where we use cascading beds, means that the sulfur is driven off primarily in a reducing atmosphere, which creates hydrogen disulfide. That's much easier to convert to elemental sulfur.

Mr. BRUCE. Mr. Smith?

Mr. SMITH. Thank you, Mr. Chairman. Let me say to the panelists, excluding Dr. Hyde—I don't mean to slight you, but I do have a special interest in Dr. Hyde's presence and I am going to direct most of my questions towards him. Dr. Hyde, in your testimony a minute ago, you mentioned the problem of insufficient Federal funds. What would be your proposal for allocating the funds we do have between research and development and demonstration projects?

Dr. HYDE. I think the allocation of the funds should represent a balanced program. All of the different projects, whether they be gas or oil or perhaps, though not part of this committee, nuclear or any other of the technologies, as the basic research is initiated, there is a great deal of risk. When we talk about allocation of funds, I believe we have to talk about risk. That means risk not only to the utilization of those funds, but to the scientists as well.

Consequently, in terms of looking at the allocation of funds to research and the development of pilot plants, and then into the commercial demonstration, there should be most cost sharing at the downstream, at the commercial demonstration. At the upstream, there should be less.

Fundamentally what we have are two inverted pyramids—well, one inverted pyramid and one upright pyramid. The inverted pyramid represents large funds for the research at the initial stage with small funds for the projects as you move downstream. The second pyramid, which is upright, would show small funds for the research and large for the downstream.

Let me be sure you understand. When I say research, development and demonstration, these actually go across the board in each of the original areas where we talk about research, development and demonstration. In many of the demonstration projects, the scale-up is an extremely serious problem.

We have one case in Texas where in the late 1960s or early 1970s, one company tried to scale up a process that worked in the laboratory, worked at the pilot plant, they spent $42 million on the scale-up and it did not work. One has to ask what the risk is, and how we assess that. Well, these are some of the problems we must address, and I see the pyramid approach as being a way that most people would understand.

Mr. **SMITH**. Thank you.

In 1990, I believe the Administration proposed an oil research program plan that had a lot to do with enhanced oil recovery. This is a basic question, but what is the advantage of enhanced oil recovery? Why should we be spending money on enhanced oil recovery techniques and not money in other areas? What is the cost efficiency argument there?

Dr. **HYDE**. We have some very serious problems in the oil production side. For example, if you take the spraberry, which caused a major oil boom in Texas in the 1950s, we are only able to produce about eight percent right now of those reserves. We must have the technology that is going to allow us to get the rest of the reserves out of formations such as that. Currently, we do not know how to frac those formations. Consequently, we need the technology to learn how to do that.

Mr. **SMITH**. What is your estimate as to the potential reserves that could be extracted perhaps in the next 5 to 10 years perhaps with enhanced oil recovery techniques that are expected to be on line?

Dr. **HYDE**. Let me just make a comment on that, and then I think the people from NIPER might be able to address that a little bit better.

Mr. **SMITH**. Okay.

Dr. **HYDE**. When we talk about enhanced oil recovery, West Texas appears to be a mature field, that is the way it is viewed by the industry, with very little upstream potential. So the entire independent sector of the oil industry views EOR as a non-economic process. We also know that we currently have technology—it is available—to increase the production by EOR methods, whether or not they be carbon dioxide or surfactant flooding.

But when we look at the surfactants, they are tied to the price of crude, because they are derived from the crude itself. Therefore the economic studies need to be initiated with regard to EOR, the research associated with that, because that is something that seems to fall through the cracks. When you are trying to improve oil production by surfactant floodings and the surfactants themselves are tied to the price of the crude, if the crude goes up, so does the surfactant. And it still remains uneconomical. I would like to ask the NIPER people to respond.

Mr. SMITH. Okay.

Mr. DETERDING. To answer your specific question on what is the potential, who is making the estimate and what day of the week, and so on—there are a lot of different estimates, depending on the kind of EOR technique you are using and so forth. One of the things we have is a system called TORIS, the Tertiary Oil Recovery Information System, which is a very complex system, including a data base, and analytical models. It does things like estimate the produceability of various EOR techniques and the economics associated with that produceability. It depends on the kind of EOR process you are using, and you will get estimates anywhere from 30 percent to 60 percent of the remaining oil in place. That's a big resource. That's been estimated to be like 340 billion barrels. That sounds like lots of energy security if you could get all that.

In terms of economics, as I say, each of these EOR techniques has its own economics associated with it. One that we have been involved with is the microbial enhanced oil recovery technique. The interest there has been basically toward the independent. We were talking about programs to benefit independents later in terms of cost sharing.

But this is a technique which has a lot of promise. It is one where we conducted a full-scale field test, including a joint venture with small independents and DOE. But it was one where the small independents could afford to participate, because the cost is low. Their basic contribution to this was the producing field itself. And that's a significant contribution, of course.

Mr. SMITH. Even though you couldn't put the exact figures on it, what I wanted to point out by the question, and you all know this so well, but I don't think everyone is aware of it, is the fact that we really extract a very small percentage of the oil and gas that is in the ground right now. Sometimes it is as little as eight percent, maybe 25 percent.

With enhanced oil recovery techniques, even if we only increased that by 30 to 50 percent, that's an incredible amount of energy that can be extracted, perhaps with a relatively small investment of enhanced oil recovery funds. So I think that's the potential that America needs to be aware of.

Dr. Hyde, let me go back to you for the next question. You and I are both aware that the Permian Basin area of West Texas, a good chunk of which is in my Congressional district, produces 17 percent of the oil produced in this country, and 11 percent of the natural gas, which is an incredibly large figure when you think of how small the area itself is.

You mentioned in your testimony that despite the importance of the region, despite how much oil and gas it produces, that no Federal energy field office, no Environmental Protection Agency field office, no Federally-assisted technology demonstration projects, no energy R&D programs of any consequence, and no direct government aid of any particular consequence are found in this particular area. That is a question that I put to Secretary Watkins and Deputy Henson Moore, who is a friend of ours in the Department of Energy, two weeks ago in this very room.

Let me ask you to try to answer the question that I asked them, which is why is it that given the importance of the area, we don't seem to be getting more support from the Department of Energy or from the Administration?

Dr. HYDE. Thank you very much, Mr. Smith. We really do not know. We really do not know, in West Texas, but I have an opinion, which I will share with you. The Basin has always produced a significant quantity of oil and gas. In the past, that has pretty much been the easy oil. It has been easy to bring out of the ground.

Therefore, there has really not been an apparent need for any help from the Federal Government, because up through the beginnings of the 1980s, it was a reasonably healthy region, with its ups and downs, as the history of the oil industry goes. In engineering and science today, we might look at those fields and we would approach them from the point of being on a first-order curve, high up on the curve, where we are trying to extract more oil and it is getting more expensive all the time.

The reality of the oil patch does not seem to be viewed as it really is, outside of the oil patch. It is very easy to look at the image of the oil patch, and sometimes its image—people have mixed emotions about it, as we might view this past election. But perhaps it is also because the Federal Government initiated its presence in the southwest in 1913, in Bartlesville.

Consequently, as technologies grew and the presence of work in the oil patches grew, the Bartlesville office and all the efforts that were up there just grew right along with it. Over the years, the Oklahoma fields built up, and then they played out a little bit. Texas fields have done the same.

But then we also have other situations that, historically, we might look at. Really what happened in the 1930's in Texas? Perhaps we don't realize that the National Guard was called out to quell the Texas riots in the oilfield in the 1930's. Texas quite often has been an extremely independent State.

I believe sincerely that what has happened is that in today's world the reality of the finances, the reality of the resource is that we need the research, the help, and the independents want and need it also. But it might also be related—it is not the Government's fault, it is not the fault of Texas, it simply has grown up this way. We have a young university there. It is only 16 years old. It does not have the resources that other major institutions have. And all of these things have influenced the lack of a strong support mechanism for this major oil field.

Mr. SMITH. Dr. Hyde, thank you. That's a historical perspective that I think is of real interest. Let me say, too, that we are working within our office to try to bring a Department of Energy field office to the Permian Basin area. That was a point I made with Secretary Watkins a couple of weeks ago. So don't give up on that, just because it has been easy to extract the oil and gas for the last several decades, it is getting harder as time goes on.

Dr. **Hyde**. We would accept a temporary one, bring it out there for five months and take it away. Bring it back two years later, that would be fine.

Mr. **Smith**. You were talking a few minutes ago about the riots in the 1930s in the oil fields. You and I were discussing before this hearing began some of the economic problems that are felt by those who live in West Texas. That's a human side that perhaps not many people are aware of. Would you explain to us what you meant by those economic problems that are felt by the West Texans?

Dr. **Hyde**. Living in Midland and working in Odessa, I see a perspective of the entire oil industry out there. I do not have any investments in the petroleum industry. I am a professor at the University and view the entire region from that particular position, which is the senior engineering academic position in the Basin.

I see the entire petroleum industry in a state of flux right now. Not only from the point of view of what the independents feel, but also from the point of view of the majors, what they feel their obligations are. The independents are adrift a little bit, because they are not quite sure what to do. I have had an independent tell me, "Tom, I wish somebody would just tell me what to do with regard to the environmental issues."

These are very serious problems that play on the psyche, that relate to the young men and women who will grow up, children of these oil men, that may or may not go into the industry in the future. So it is very serious in terms of the way in which the psychological impact of these last five to seven years are affecting the industry. I think we will see a long-term effect.

Mr. **Smith**. Dr. Hyde, thank you for your contributions today.

Thank you, Mr. Chairman.

Mr. **Bruce**. Thank you, Mr. Smith.

Mr. Deterding, in your testimony, you indicated that you would like to see a 50 percent increase in the R&D budget for enhanced oil recovery. How did you come up with the need for an additional $24 million, and how would you spend it if they came in and gave it to you?

Mr. **Deterding**. We do have some rationale behind this. In terms of the enhanced oil recovery increase we recommended, I think I mentioned that I was concerned about long-term fundamental research being impacted. We don't want to see that happen.

So we are saying $3 million should be devoted to long-term EOR research. We believe that the cost shared field tests that have been outlined are inadequate, that there should be more of them. Those are expensive, to test some of these EOR techniques. We have indicated a $6.7 million number to increase the number of field tests, and then the technology transfer that I referred to earlier, particularly as related to the small independents, we said $1 million. That's the $10.7 million, roughly $11 million over and above the budget request as it is in there now.

Mr. **Bruce**. Okay, thank you.

Dr. Derbyshire, I was curious—can you give me a brief description of the difference between Eastern and Western shales, the shale characteristics and the cost produceability? What is the difference between the shales?

Dr. DERBYSHIRE. Yes. I think one of the slow factors in developing technology for Eastern shale was that it was assumed to be similar and could be processed similarly to Western shale. It was only when we started to realize that different technologies were required because they are different, the organic matter behaves somewhat differently. We need higher temperatures to produce oil yields.

There is a somewhat different balance of oil and gas compared to the Western shale. The Eastern shale rock is a silicate and it tends to stay together. One reason that is particularly useful is that we can use efficient fluidized bed technologies to process that shale that can't be applied to the Western shale because it essentially falls apart. Not only does it fall apart, but those carbonate rocks tend to release a lot of carbon dioxide at their operating temperatures.

That's essentially a very brief explanation of some of the main differences and why we have had to look at quite different technologies. We can't process Western shale by this process approach.

Mr. BRUCE. How do the costs on produceability compare?

Dr. DERBYSHIRE. The costs by recent estimates have come out the same. In fact, according to a Foster-Wheeler estimate that was sponsored by the Department of Energy last year, we were actually looking at something like $2 per barrel—you can do what you like with these numbers—$2 per barrel cheaper for Eastern shale in that scenario.

Mr. BRUCE. And the reserves of Eastern shale versus Western shale—what are we looking at?

Dr. DERBYSHIRE. They are roughly equivalent.

Mr. BRUCE. Okay.

I thank the panel for your testimony. If you guys ever want to start a consulting firm, I think it would be great, you would have Hyde, Deterding, Derbyshire and Burchfield. That would work out very well. Anyone could say that and it would sound very distinguished.

I appreciate your testimony, and this hearing is concluded.

[Whereupon, at 11 a.m., the hearing was concluded, to reconvene at the call of the Chair.]

# APPENDIX

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COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY

HEARING ON DOE'S FY 1992 REQUEST FOR OIL AND NATURAL GAS RESEARCH AND DEVELOPMENT PROGRAMS

MARCH 14, 1991

Madame Chairman, today we convene to continue to look at the FY 1992 request for oil and natural gas. After hearing from the Department of Energy's witnesses, we have the honor of hearing from our distinguished witness from private industry. Madame Chairman, I would also like to take this time to welcome our colleague, Congressman Mike Synar.

Today we will examine the budget for petroleum research, gas research and oil shale work, all which are vital as we try to develop a national energy strategy.

Madame Chairman, I thank you for calling this hearing.

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# OPENING REMARKS
THE HONORABLE TERRY L. BRUCE
SUBCOMMITTEE ON ENERGY HEARING
FOSSIL R & D - OIL AND GAS
MARCH 14, 1991

THANK YOU, MADAME CHAIRMAN. I WOULD LIKE TO THANK OUR WITNESSES FOR BEING HERE TODAY TO ENLIGHTEN THE MEMBERS OF THIS SUBCOMMITTEE AS TO THE RESEARCH AND DEVELOPMENT NEEDS OF THE DOMESTIC OIL AND GAS INDUSTRY.

WHILE I DO NOT FIND THE PRESIDENT'S NATIONAL ENERGY STRATEGY (NES) TO BE ADEQUATE, I FIND EVEN MORE UNSETTLING THE FACT THAT THE PRESIDENT'S CANNOT RECONCILE HIS PROPOSED BUDGET WITH HIS VERSION OF THE NES. FOR INSTANCE, THE PROPOSED BUDGET REQUESTS ONLY $52 MILLION FOR ENHANCED OIL RECOVERY PROGRAMS FOR FISCAL YEAR 1991. I AM INTERESTED IN HEARING THE VIEWS OF OUR DISTINGUISHED WITNESSES AS TO WHY THIS IS SO, AND WHAT AFFECT IT WILL HAVE ON OUR DOMESTIC OIL INDUSTRY, WHICH IS DOING ALL IT CAN TO COMPETE WITH THE IMPORTED OPEC CRUDE.

FURTHERMORE, I AM DEEPLY CONCERNED WITH THE DELETION OF FUNDING FOR THE OIL SHALE PROGRAM. I LOOK FORWARD TO FURTHER EXPLORING THE RAMIFICATIONS OF THIS WITH OUR DISTINGUISHED PANELISTS.

THANK YOU, MADAME CHAIRMAN.

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